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PROPOSAL

HAMILTON-SCOURGE
PHOTO/BOTTOM/ARTIFACT SURVEY

✓ Proposal for 1980
Fieldwork program on
Hamilton-Scourge project
by Can-Dive Ltd

PC785 - remote focus
+ date back option
moderate wide angle

Respectfully submitted by:
CAN-DIVE SERVICES LTD.

Douglas R. Ersey

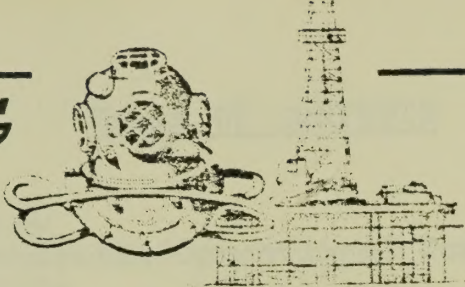
Douglas R. Ersey, P. Eng.
Manager - Eastern Operations.

January 1980.

[Signature]

CAN DIVE

CAN DIVE OCEANEERING



CAN - DIVE SERVICES LTD.

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MISSISSAUGA, ONT.
CANADA L4T 3W4
PHONE: A. C. 416 - 671-1883

Hamilton-Scourge Steering
Committee,
City Hall,
71 Main Street West,
HAMILTON, Ontario,
L8N 3T4

January 25th, 1980.

Dear Sir,

As requested, I am submitting to you the results of our
proposal for the Hamilton-Scourge Photo/Bottom/Artifact
Survey.

Can-Dive Services would like to take the opportunity
of thanking you for allowing us to bid on the project and
hope that we can be of some service during the course of
this interesting endeavour.

If you should require any additional information
pertaining to the proposal or otherwise, please do not
hesitate to contact me at (416) 671-1883.

I remain,

Yours truly,
CAN-DIVE SERVICES LTD.

A large, stylized handwritten signature in dark ink, appearing to read 'Douglas R. Elsey'.

Douglas R. Elsey, P. Eng.
Manager,
Great Lakes Division.

DRE/dk d

Encls.

Subsidiary of
OCEANEERING



INTERNATIONAL INC.

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1.0 OVERVIEW

The photographic assessment of historical artifacts undersea is a newly emerging field. For centuries divers have been used to investigate sunken ships, but the goal was to salvage - by whatever means were most expeditious - the vessel's cargo. Photographic documentation and sampling and scientific investigation of a vessel's components, using the least non-destructive techniques, made its first recorded appearance in 1960. Prior to this time, and beginning with Louis Boutan in 1892, all such work consisted of simply photographing the vessel at random locations and taking whatever artifacts were readily available and transportable by a diver.

In 1960 a team from the University Museum of the University of Pennsylvania, headed by Dr. George F. Bass, began the first systematic and scientific examination of a sunken vessel - a seventh century Byzantine shipwreck at Yassi Ada, Turkey (1, 2). Initially scuba divers conducted the photographic reconnaissance and excavation during the 1961-1964 period. Subsequently, in 1964 the manned submersible ASHERAH was brought to the wreck site and, using 70mm cameras, produced a stereo-photographic mosaic of the wreck in situ. Preliminary assessment of the wreck area was conducted by side scan sonar. To navigate or position itself relative to the wreck a rigid, open framework or grid was installed over it which provided photo reference points. The average depth of the wreck was 36m and visibility ranged from 2.5 to 3 meters.

A more recent and on-going assessment concerns the stereo-photographic mapping and excavations on the sunken U.S. ironclad MONITOR (3). Sunk in 67m of water during a storm in 1862, MONITOR was found and identified in 1973. The MONITOR investigation is the most extensive underwater archeological program to date and, therefore, it warrants a closer look into the tools and techniques being employed.

Preliminary observations were by lowered television and still cameras, the camera system was fouled in the wreck and recovered four years later by divers from a lockout submersible. In 1977 a major expedition was mounted to photographically assess MONITOR's condition using the lockout submersibles JOHNSON-SEA-LINK I and II (J-S-L). The mission objectives were to map, photograph and retrieve artifacts in and around the wreck. The project was divided into two phases:

- 1) a reconnaissance and fact-finding mission and
- 2) providing a full photographic stereo-mosaic of the wreck.

The first phase involved initial employment of a side scan sonar to image the bottom and determine the presence of obstructions adjacent to the MONITOR that would hinder submersible operation. Upon completion of the side scan survey, the Harbor Branch SEA GUARDIAN/CORD system was used to directly examine the wreck. This system consisted of the CORD, a remote-controlled submersible vehicle, equipped with a low light-level television camera; and the CORD's tender, SEA GUARDIAN, a small surface vessel carrying electronic, station-keeping equipment. Video tape recordings were made of the MONITOR by CORD to insure that the wreck was clear of debris that might entangle a manned submersible. CORD also gathered data on ocean currents, temperatures, and visibility around the wreck site.

The second phase called for the operation of two lock-out submersibles (J-S-L I and II) working in tandem to complete several tasks. The first was to establish a photographic baseline on the north side of the wreck. Sub II was used to lock out a diver while Sub I served as a safety vehicle and escorted the diver as he installed the baseline. The latter consisted of $\frac{1}{4}$ inch polypropylene line marked at 1.5 meter intervals. Stakes were pushed into the sand to anchor the line securely to the ocean floor. Next, a series of numbered buoys were attached at the 1.5m interval marks from stern to bow. The buoys were numbered from one through thirty-nine. The baseline and buoys were used as departure points for the sub pilots and provided orientation for their stereophotographic passes over the wreck.

Photographs were taken with a stereo camera array using vertical, athwartships passes over the wreck. The submersible was trimmed 4.6, 5.5 and 6.1 ^{units of} ~~over the sea~~ ^{What} floor, depending on which cross-section of the wreck it was passing over. This procedure was adopted because the wreck is at an angle to the bottom with the stern higher than the bow. Oblique photographs were also taken along the armor belt on the portside of the ship. This was done by utilizing each of the numbered buoys on the bottom to orient the sub at right angles to the wreck.

MONITOR's dimensions are about 52 by 14m. The prevailing current at the wreck has been estimated to be about 0.4 knots (20cm/sec) in a north-south

orientation. Visibility varies from 3 to as much as much as 10m. With these general project parameters in mind, a photographic survey was designed to provide data from which photogrammetric reduction would produce the wreck. These co-ordinates in turn provided a record of the existing dimensions of various portions of the wreck from which the archeologists and naval architects could infer engineering design, condition, and other little known information.

The safest, most efficient, and reliable method of obtaining photogrammetric coverage under these conditions was considered to be a rigidly mounted camera pair on a manned submersible. Physical dimensions of the vehicle dictated the separation distance of the cameras, while light source coupled with lens design constrained the area coverage. Based on past experience from other photographic missions, coupled with the physical size of the J-S-L, the camera configuration was designed with a nodal distance separation of 1.79m, and the camera pair were attached to the front of the vehicle in a vertical orientation. Additionally, the mount was designed to allow for a common 90° rotation of the two cameras (maintaining their relative orientation) to a forward looking attitude. Strobe lights were mounted with the cameras in such a way that usable imagery would be produced throughout the format of both so that the film speed-aperture combination would produce optimum contrast at 4.6m. Minimum time between exposures was constrained to 5 seconds by the recycle time of the Strobe lights.

The cameras were two Edgerton Deep-Sea, Model No. 372's having a standard 35mm film format and effective focal length in water of about 35mm. The cameras were mounted to provide a 54° angle of view in the cross track direction and 42° along the track. The J-S-L had a pressure-depth sensing device capable of indicating relative differences in depth with a standard error of about ± 15 cm. This device was recordable (manually) at the instant of exposure and its read-out, along with vehicular attitude measurements, was used to determine the position of the camera exit node relative to a constant pressure surface during the photographic mission.

With a camera separation of 1.79m, a flight line spacing of 1.5m allowed for about 10 percent deviation in flight path and still realized complete stereo coverage when operating at a nominal 4.6m

flight altitude. For flight line control then, a base line was fixed to the sea floor as described on previous page. The line was placed a nominal 4.6m from the hull so that each of the resulting 38 photo stations could be used to control the oblique photography mission. For this reason, the constant 1.5m spacing was maintained, even though this configuration resulted in an increase in the number of overhead flights. To assure full coverage, the exposures for each overhead flight line were started when the vehicle passed over the base line. With velocity of the vehicle of about 50cm/sec (0.97knots), exposures were made at about 1m intervals. Approximately 4000 black and white and color 35mm stereo photographs were taken vertically and obliquely under these controlled conditions. Diver hand-held photographs were taken of selected parts of the wreck.

at recycle
of 5 sec, the
spacing become
2.5m

use relative
V of 20 cm/sec
against current.

A subsequent mission designed to excavate into the MONITOR was conducted by lockout divers/archeologists from J-S-L in the summer of 1979. A part of this mission was to ascertain the feasibility of salvaging the vessel. It was deemed unsalvageable.

Remotely Operated Vehicles (ROVs) have been used as major tools in archeological investigations, instead of augmenting data obtained by a manned vehicle as described above. Rebikoff (4) discussed the use of the ROV POODLE in discovering and examining two Phoenician wrecks off Cannes in 1956 and, in other reports, in observation of alledged sunken cities off the Bahamas.

In a 1975 Test Report (5) Roe and Sandilands described ROV TROV investigations of the HAMILTON-SCOURGE site. The operations were not designed as an archeological expedition, but were undertaken as a part of TROV's sea trials. Several incidents related to observation in the above report, regarding the environment and the operating conditions, bear heavily on the choice of tools and techniques advanced in this proposal.

Other than these reported incidents where manned vehicles were used to conduct systematic, controlled photographic surveys of historical objects, the vast majority of archeological investigations have involved the use of scuba equipped divers. While these projects received limited funding support individually, collectively they represent the preponderance of underwater archeological investigations. Equipment

limitations have, in the main, restricted these investigations to shallow (30m or so) waters, hand-held equipment and in areas of substantial underwater visibility (3 or more meters) and low currents (2.5cm/sec or less).

At this point in time there is little in the way of precedent which has been established in the conduct of underwater archeological investigations. Based on limited experience available, the following protocol can be seen to have been followed regarding the sequence of events and efforts:

- 1) Side scan sonar survey to delineate the wreck area and locate the wreck's position.
- 2) Divers or remote TV to positively identify the wreck and conduct a preliminary reconnaissance of the working conditions.
- 3) Establishment of a grid or network of buoys/lines about the wreck for navigational purposes.
- 4) Deployment of a manned submersible to obtain a photographic mosaic of the wreck by still photography, and to take selective photographs of various wreck features.
- 5) Divers to excavate and/or collect artifacts of historical significance.

While these procedures and techniques are not necessarily the only means for successfully conducting an underwater archeological investigation, they do provide guidance in the approach to be taken to the HAMILTON-SCOURGE project.

2.0 ENVIRONMENTAL/OPERATIONAL CONSIDERATIONS

There are a host of problems which confront the underwater archeologist; in the main they can be ascribed to lack of or insufficient knowledge of the operating area. Owing to chronic funding limitations, few, if any such endeavors are preceded by the extensive surveys which would be required to know and predict the operating environment prior to beginning the operation. In most instances the investigators develop a plan of attack based on cursory knowledge and then modify this plan as real in situ conditions dictate. The HAMILTON-SCOURGE project is no exception. While considerable data is available in some areas (sediment type, surface conditions, physio-chemical water characteristics), it is severely lacking in others (visibility, currents). The purpose of this section is to identify the major natural and man-derived potential problems in the HAMILTON-SCOURGE area.

2.1 SEA STATE

The state of the sea exerts its major effect on launch/retrieval of equipment and vehicles, and on the simple physical aspects of working aboard an unstable platform. The sea state data available does not indicate that sea states will be a major problem in the operating area. Under average summer month wind conditions, the 0.5 to less than 1m significant wave heights generated should not present a problem. Summer storm conditions which can develop very short period waves of 1 to almost 2m can present a problem, and it will probably be necessary to curtail operations during this period, particularly at the higher range of the 1 to 2m spectrum. *data provided*

2.2 UNDERWATER VISIBILITY

Underwater vsibility has a direct and overriding influence on the entire project since the ability to see and to employ optically imaging systems is governed by range of visibility. Visibility data for the HAMILTON-SCOURGE area is inadequate to set up a pre-conceived and inflexible viewing and photographic program. The best available water clarity data indicates 1 to 2m viewing range, but this is dependent upon a host of factors (e.g. currents, productivity, bottom disturbance, Niagara River run-off) which vary both temporally and spatially. In view of this lack of data and the fact that water clarity can change from day-to-day, viewing and photographic devices and

lighting will be initially arranged based on 1.5m viewing range, but will have the capability of being modified on the site to accommodate variations in water clarity.

visibility may be so bad - lighting is the key - reasonable?

2.3 CURRENTS

Water currents exert a major effect on every aspect of undersea work and are almost as crucial as water clarity to this project. Certain data available from the HAMILTON-SCOURGE area indicates bottom currents in the neighborhood of 4 cm/sec (0.08 knot), this current regime is quite acceptable. However, observations from the TROV 1975 Tests (5) report a current of 100 to 150 cm/sec (2 to 3 knots) at 90m depth running east-to-west. Under these conditions work becomes difficult and, if the underwater vehicle is subject to high drag forces it can become impossible. (TROV was forced to terminate operations owing to lack of forward progress under the currents reported). Currents of 100 cm/sec and higher can also effect visibility by disturbing the bottom sediments and reducing water clarity.

The only approach, in lieu of adequate data, is to modify the operations to accommodate the currents. Under certain conditions a fast current can be helpful instead of hindering, in that, if the bottom is inadvertently disturbed by vehicle contact, the current will carry the suspended sediment out of the way before it obscures visibility. Photographic and/or television transects must therefore be designed to take advantage of the current rather than result in a confrontation. Since water currents, similar to water clarity, vary within short periods, decisions concerning how to work within the prevailing current regime must be made on an almost daily basis.

currents not major problem at bottom - why to be problem at cable depth?

2.4 NAVIGATION/POSITIONING

There are a variety of techniques which can be employed to determine a position underwater. The most sophisticated of these are acoustic positioning systems which can be bottom-mounted (long-base line) or surface-ship mounted (short baseline). These systems are summarized and discussed in reference (6). Other non-acoustic positioning/navigation techniques include: visual observations of known reference points, magnetic compasses and gyrocompasses and, in a few instances, acquiring and following a cable or pipeline by virtue of the electromagnetic or the magnetic signatures emanating therefrom.

In the Field Work Statement for the HAMILTON-SCOURGE project acoustic positioning is discouraged owing to high cost of set-up and operation. Acoustic positioning provides, however, the most accurate means of positioning (+1m relative to bottom-mounted transponders) in the absence of visually-attainable, known reference points. Since pipeline and cables are absent in the project area, the only positioning techniques remaining are from known reference points and magnetic or gyrocompass bearings. A Navigation scheme is described in the following section which takes advantage of the wreck's features and impressions made in the bottom sediments.

The Field Work Statement suggests a temporary semi-rigid reference framework to be established over each vessel. We would discourage this approach since the complexity and difficulty in setting up such a reference framework underwater is time-consuming and requires the employment of a diver, therefore it will be quite expensive. Our approach to vessel photography favors that employed in the MONITOR survey. this approach is also explained in the following section.

2.5 ENTANGLEMENT

Concern was expressed during the bidders meeting that all possible caution be taken to avoid affecting the vessels and their component parts. One of the most likely means of causing disturbance is by entanglement (with, for example, the tether cable of a remotely operated vehicle) or by collision with the wreck. TROV experienced a number of entanglement/collision problems in the HAMILTON-SCOURGE area. At one time it collided with a vessel's hull (owing to restricted visibility, and twice it became entangled. (During one entanglement it fell on the wreck and tumbled down a companionway some 2 to 3 meters.)) The entanglement problem is ever-present when operating around structures with ROVs or tethered submersibles. Reference (6) reports that 18 out of 20 ROV operators have tangled either the vehicle or its cable on structures they were inspecting. This problem is a distinct possibility owing to the 16 to 20m of mast height and 12m of bowsprit on the HAMILTON.

It is possible that at one time or another even a vehicle with no tether cable will become fouled in the HAMILTON or SCOURGE. The consideration, therefore, is whether or not to jeopardize human life by using a

manned system instead of an unmanned or Remotely Operated Vehicle. In view of the fact that we propose, in addition to a manned vehicle, incorporating an ambient pressure diving system into the projects inventory, there will be rescue assistance available at all times during this project. Since the most likely object a manned vehicle will foul on are natural fiber lines, cutting the vehicle free will not present a problem to the diver. (A total of 96 hours life support/submersible occupant is available.) The likelihood of fouling, is considerably reduced with a non-tethered system. The possibility of fouling or entangling with a tethered ROV or submersible is virtually a certainty. In both circumstances, divers will still have to be dispatched to free the vehicle to assure that no damage is done to the vessels. The choice, therefore, is whether to put up with the occasional fouling of a manned vehicle or the frequent fouling of a tethered vehicle with the attendant delays and costs. Under these considerations we favor the manned untethered vehicle. If, however, the wrecks can be shown to be free of lines and rigging, then an ROV of the TROV variety would be employed since the chances of fouling would be considerably reduced. 04.

2.6 MANIPULATION

There is no present substitute for the human hand underwater. In spite of several remarkable manipulative devices developed in the past few years, none can approach the tactile senses, manipulative dexterity and memory embodied in the human hand. Consequently, any coring or sampling of the vessels hull or spars which might be attempted by mechanical manipulators must be carefully planned and demonstrated prior to its actual application in situ. The diver is obviously the best capability to deploy for this task. However, prior to his deployment the vessel must be clearly marked and referenced so that the diver spends the majority of his bottom time working, and not looking for the work site. ✓

2.7 SOIL BEARING STRENGTH MEASUREMENTS

Sediment data available indicates that bearing strength measurements can be taken in situ with a hand-held vane shear device. This type of measurement is only applicable in cohesive materials, the presence of sand renders the technique inadequate. There are, however, two other considerations which must be dealt with.

The presence of gas in the sediment (which is possible since the sub-bottom sediment is described as a reducing environment) introduces errors since the gas may escape as the vane is inserted and affect the bearing strength readings. It may be more appropriate to collect "undisturbed" cores and analyze the sediment on the surface. The second problem is introduced as the vane is sunk deeper into the sediment. In this case the sediment friction on the rod which drives the vane may cause higher readings.

YES

NOT likely

3.0 TECHNICAL APPROACH

The preceeding section emphasized the uncertainties which accompany this project. This section describes techniques which will be employed to satisfy the Field Work Statement. It is re-emphasized, however, that the survey program and techniques must be extremely flexible to accommodate changes in the environmental conditions. Therefore, the following approaches contain, in some instances, optional devices and techniques to meet potential changing requirements.

3.1 SUPPORT BASE

Operations will be staged out of Port Dalhousie. A vessel will be moored at the project site which will serve as the daily support base. The vessel will have on board accommodation for a maximum of ten people. A small 35' work boat will be available to transport any additional personnel to Port Dalhousie on an "as required" basis. Depending on the situation, all or part of the survey crew may elect to remain on board overnight to effect repairs or changes to the equipment.

The vessel will support and maintain all diving operations and equipment. Radio communication between it and Can Dive's shore base will be maintained continuously during the operational periods. It will be moored (2 or 4 points depending on conditions) on the boundary of the operating area, or 75m from the mid-point of each wreck, to assure that the wrecks are not damaged by the mooring anchors during emplantment and that they are not damaged by equipment which may be inadvertantly dropped during operations. The mooring anchors will be outside the area of interest to prevent undue disturbance of the bottom. A del Norte *Surface* transponder navigation system will be used to position the barge relative to the wrecks mid-points.

3.2 UNDERWATER VEHICLE/DRIVER CAPABILITIES

Two primary capabilities will be used to obtain the photographic and TV documentation and conduct the sampling and measurement program, these are: the manned submersible SEA OTTER and ambient pressure divers.

3.3 SEA OTTER

SEA OTTER is a 3.2 ton, 2 man, 457m depth-capable

manned submersible (its characteristics and specifications are included in Appendix A) which has an operational record of approximately ten years. SEA OTTER will be used to obtain TV documentation of the lake bed adjacent to the wrecks and to obtain TV/photo documentation of the wrecks themselves.

The choice of an untethered, manned submersible rather than a ROV or tethered submersible is based on the fact that when working around the wrecks the possibility of fouling is minimal. A second major consideration is that no underwater television system presently available can equal the human eye in terms of resolution, depth perception and color rendition. The major advantage an ROV or tethered submersible offers is unlimited power. In this particular project this advantage is outweighed by the entanglement and, hence, damage potential of the vehicle's cable and/or life support systems in the care of a tethered submersible. Furthermore, the area is small enough such that alternatives to conventional submersible operations are available that will extend the vehicle's normal operating duration.

Documentation of the lake floor will be obtained by an externally-mounted TV camera which receives its power and control from the surface via a 305m long cable. The submersible, in this instance, will act as a platform to carry the TV system. Focusing control and video taping will be accomplished aboard the vessel. Communications and directions to SEA OTTER will be via an underwater acoustic telephone. An additional photographic capability will be provided by the observer in SEA OTTER, in that, they will carry hand-held 35mm or 70mm cameras inside the vehicle (connected to an external strobe) to obtain close-up, detailed color photographs of objects of interest. Concurrent with TV and photographic documentation, the observer will tape record his observations to provide supplementary data. By obtaining TV and lighting power from the surface, virtually all of SEA OTTER's battery power can be used for propulsion during the lake floor survey.

Photographic and TV documentation of the wrecks will be accomplished by SEA OTTER using an externally mounted 70mm camera with strobe light, and a hand-held TV inside the vehicle. All power and control function for cameras and TV will be provided by the submersible. By this approach the vehicle will offer the least possible potential for fouling the wrecks and damaging their components.

3.4 AMBIENT PRESSURE DIVING CAPABILITIES

Divers will be employed to obtain selective photography of the vessels, sediment bearing strength measurements, samples of the hull and other artifacts, to install the wreck navigation/buoy array and to provide immediate rescue capabilities should entanglement of the submersible occur. Diving will be conducted from a bell lowered and raised from an A-frame on the vessel. The use of a bell dive system to conduct ambient pressure diving to these depths is dictated by federal offshore regulations. To use any other method of conducting ambient pressure diving at this depth would show almost total disregard for diver safety and be contrary to the best interests of the client. Any loss of life due to negligence or economic considerations would be intolerable.

An alternative to bell diving would be lockout diving from a submersible. In this case, the lockout diver would be subjected to ambient pressure at depth and the operator/observers would be in an one atmosphere environment. The submersible operator should not be subjected to ambient pressure in order that he may effectively render assistance should a problem with the diver occur. If there was an occurrence of "bad" gas to the diver (and therefore also the operator), or if there was an occurrence of decompression sickness on ascent - a malady that would most likely face both the diver and the operator if both were subjected to the same decompression schedule - then serious problems could evolve.

In light of the above, we at Can-Dive feel that the only safe, efficient way to conduct ambient pressure diving is with a bell or a conventional lock-out submersible. In both cases, a recompression chamber is required on board the support vessel to transfer the diver under pressure to a double lock decompression chamber. (Decompressing the diver either in the bell or the lock-out compartment is unsafe as well as being contrary to federal laws both in the United States and Canada). The reason is that should medical assistance be required for the occupants (who, in this case, would be decompressing in a single lock decompression chamber - an outlawed piece of diving hardware) then there would be no way to lock in medical personnel.

Periodic ambient pressure diving in support of the submersible operation would be both time and cost effective when it comes to performing some of the tests/programs required by the client. Should the client

disagree, then we are open for discussion on alternative methods.

3.5 PHOTOGRAPHIC/TV INSTRUMENTATION

The following instruments for obtaining TV and photographic documentation will be made available:

- a) Model 125 Diver Inspection Television System (Hydro Products) (black and white.)
- b) Model PC-785 70mm still camera (400 exposures/roll) with strobe (Hydro Products.)
- c) Model PC-775 diver hand-held 70mm camera (400 exposures/roll) with strobe (Hydro Products).
- d) Hasselblad, 70mm camera (70 exposures/roll) motor driven, hand-held or remote control.
- e) Nikon 35mm camera (36 exposures/roll), 24mm lens.

Big
Format but
not wide-angle

Specifications for the Television System and the PC-785 camera/strobe are presented in Appendix A. These two devices and the Nikon camera will be employed aboard SEA OTTER. The PC-775 and Hasselblad will be used by the divers subsequent to submersible operations. All still camera film will be taken to Toronto at the end of each work day where 8 x 10 prints can be made within a 30 hour period. Contact prints of the processed film will be made aboard the vessel.

3.6 NAVIGATION

The overriding consideration in designing a navigation scenario for this project is the discouragement of an acoustic system. Ordinarily a 3-transponder, bottom-mounted net would be selected, but for reasons of economy an alternate technique has been chosen which will produce the results desired with minimal disturbance to the lake bed. Two different navigational techniques will be employed, one for the lake floor and one for the vessels.

3.7 LAKE FLOOR

Navigation in the wreck vicinity (out to 75m from the mid-point of each wreck) will take advantage of two devices: a magnetic compass and a wheel odometer. The compass will be used in a conventional manner to provide course direction. The wheel odometer or

Unigator (Unicycle Navigator) has been used previously on submersibles in Canada and the U. S. and is described in detail in Reference (7). Basically the Unigator consists of a bicycle wheel frame connected to an odometer or other device to record and display wheel revolutions (each full revolution producing a linear distance measurement) at the submersible's viewport. The wheel is connected to a rod (2 to 3m length) which is mounted on a universal joint on the vehicle to permit 360 degrees rotation in the horizontal and approximately 80 degrees in the vertical. As the submersible proceeds along a course dictated by the compass, the wheel, in contact with the bottom, revolves to produce a readout of distance travelled. On a level, essentially flat, bottom such as that present in the HAMILTON-SCOURGE area, this distance measurement is highly accurate. The wheel's weight can be adjusted to obtain maximum results with minimal bottom disturbance.

During the lake floor portion of the survey parallel tracks will be run which will be spaced at 1.2m (4 ft) intervals to obtain, at a minimum, the 80 percent coverage required. Track spacing will be obtained by impressions left in the lake floor sediments by SEA OTTER's skids. At the beginning of each track, SEA OTTER will be ballasted until it is just slightly negatively buoyant. When the vehicle is underway the skids will leave an impression which can be paralleled by the vehicle on the return run. In this manner the lake floor can be observed and TV/photographically documented. If objects of interest are seen by the observer the vehicle can stop, examine, photograph and position them (retrieval of objects can be conducted, depending on size). Following this the submersible may detour around or go over objects to regain its original course.

The TV camera during this evolution will be attached on the brow of SEA OTTER a vertical distance of 1.5m above the bottom. This will produce TV coverage of an area 1.5m (4.9 ft) by 1.3m (4.3 ft), horizontal and vertical (x, y) orientations, respectively. Track spacing of 1.2m will produce side overlapping of the video tapes of approximately 20 percent. If visibility ranges greater than 1.5m are present then SEA OTTER can be made slightly positive to "fly" higher off the bottom to obtain greater TV coverage. In this instance the Unigator's wheel and connecting rod will provide the necessary downward force to control its altitude, and the wheel impression will be used for track identification (this technique has been used on the bathyscaph TRIESTE and the submersible BEN FRANKLIN.)

Initially the lake floor survey will begin at the wreck and proceed outward to the limits of the area. A pinger will be affixed to the wreck which will serve as a reference marker and location device. At the beginning and end of each track a bearing to the wreck will be taken by SEA OTTER's directional hydrophone to further aid in track location. At the end of each day's run a pinger will be deployed to assist in locating the start point on the following day. A schematic of this scenario is presented in Figure 1.

It should be noted that the above navigational approach was designed as an alternative to acoustic positioning. If acoustic positioning became a viable option, a bottom-mounted transponder system, such as produced by Mesotech, would be employed. In this event, the application of an ROV would be feasible (since entanglement in this area is unlikely) and would take precedent over a manned vehicle.

3.8 WRECKS

To obtain the desired photographic coverage of the wreck (70 percent) the approach used will parallel that used in the MONITOR investigations. At the base of the HAMILTON, a 38m (125 ft) long polypropylene line, marked and buoyed at 1.2m (4 ft) intervals will be installed and anchored by a diver a distance of 3m (10 ft) from the wreck and parallel to it. Overflights of the wrecks at 6.5 (21.5 ft) altitude or approximately 1.5m (5 ft) above the deck will be made. (All wreck photography will be made with 70mm, color film for greatest possible resolution and coherence. Black and white TV will be taken from within the vehicle for backup data.) Line spacing will be at 1.2m. This will assure sidelap of 13 percent since the photographic coverage will produce an image of a 1.4m by 1.4m (4.6 x 4.6 ft) area. The runs will start at the buoyed line and terminate when the wreck is overflown on an athwartships course.

The reference line will be placed on the downslope side of each vessel and the submersible runs will parallel the upward sloping deck. In the case of SCOURGE (sloping 18° to starboard) the difference in altitude from the starboard to port railings is approximately 1.94m. This difference will require that the submersible make its athwartship runs at an ever increasing altitude in order to maintain its abovedeck distance of 1.5m. Depending upon the debris (spars, rigging, lines, etc.) associated with the wrecks, it may be necessary to proceed step-by-step rather than

fly a continuous track across the vessel. (A downward-looking echo-sounder on SEA OTTER will be used to monitor height above the deck.) The exact procedure cannot be stated until a reconnaissance of the wreck is conducted.

Speed of the vehicle will be maintained at no greater than 20cm/sec (0.4 knots), at this speed one exposure every six seconds will produce a forward lap of approximately 13 percent. A total of 32 tracks athwart the HAMILTON will be made (SCOURGE, being a shorter vessel, will require 25 tracks). Seven exposures, at 1.5m altitude, will be necessary on each track. Therefore a maximum of 224 exposures will provide a full-coverage mosaic of the entire wreck from a horizontal plane (since approximately 12m of the wreck's length overall is bowsprit, it may be possible to photograph this portion along its major axis only and reduce the number of photographs by some 69 exposures). The mast will be photographed by slowly ascending up its length on opposite sides. A schematic of this phase is presented in Figure 2.

A full-coverage, overlapping photomosaic will also provide a positioning tool whereby any deck features can be located on the mosaic within ± 3 percent of any dimension.

Following the submersible overflights, divers will be deployed to obtain detailed photography of selected wreck objects. This selection can be made by the on-site contracting representative.

3.9 SAMPLING

All sampling, non-destructive and otherwise, will be accomplished by divers. Since the exact location and nature of the sampling is unknown at this time, it is premature to specify the type of sampling or coring devices necessary. When such information is available, the necessary tools will be fabricated at Can-Dive's Mississauga facility. Likewise will pressure containers be fabricated when and if they are deemed necessary for artifact recovery.

3.10 SOILS MEASUREMENTS

Bearing strength measurements will be taken by divers with hand-held vane shear devices. The location of measurement stations around the hull will be designated by the on site contracting representative. The depth of measurements will also be designated by this individual at the earliest possible time so that a

particular rod length can be specified and fabricated.

The following schedule represents the sequence of events and time allocation required to conduct the proposed work (bearing adverse weather). In some instances the time allocated is simply a best guess. This is particularly true in the artifact sampling area and silver photography, since at this time the scope of this effort is unknown.

Installation of Port Bathythermograph	1 day
Large Depth Chart	1 day
Test Calibration (to be specified by Contracting Rep.)	1 day
Large Depth Chart/Logging at Site 1	1 day
Install reference line/ginger	1 day
Reconductor vessel (silver)	1 day
Conduct vessel photography (submersible)	1 day
Conduct large test survey (submersible)	1 day
Conduct vessel photography (silver)	1 day
Artifact sampling (silver)	1 day
Soil measurement tests (silver)	1 day
<u>SPRINT NO. 1 COMPLETE</u>	

Reconductor/Work Large at Work Site 1	1 day
Install reference line/ginger	1 day
Reconductor vessel (silver)	1 day
Conduct vessel photography (submersible)	1 day
Conduct large test survey (submersible)	1 day
Conduct vessel photography (silver)	1 day
Artifact sampling (silver)	1 day
Soil measurement tests (silver)	1 day

SPRINT NO. 2 COMPLETE

Installation	1 day
--------------	-------

Total Estimated Working Days 15 days

If it can be shown that the wrecks are free of drifting and lines, then we propose employing a 'TROP' type boat. In this instance - involving scientific navigation is still not desirable - the approach and the schedule outlined above will still be followed. The only exception would be to mount all equipment in-water rather than in-boat.

4.0 OPERATIONAL CHRONOLOGY

The following schedule represents the sequence of events and time allotments required to conduct the proposed work (barring adverse weather). In some instances the time allocated is simply a best guess. This is particularly true in the artifact sampling area and diver photography, since at this time the scope of this effort is unknown.

Mobilization to Port Dalhousie	5 days
Barge Deployment	1 day
Test Evaluation (site to be specified by Contracting Rep.)	2 days
Barge Deployment/Moorings at Site 1	1 day
Install reference line/pinger/ reconnoiter vessel (diver)	1 day
Conduct vessel photography (submersible)	3 days
Conduct lake bed survey (submersible)	12 days
Conduct vessel photography (diver)	1 day
Artifact sampling (diver)	2 days
Soil Measurement tests (diver)	1 day
<u>WRECK NO. 1 Complete</u>	
Relocate/Moor barge at Wreck Site 2	1 day
Install reference line/pinger/ reconnoiter vessel (diver)	1 day
Conduct vessel photography (submersible)	3 days
Conduct lake bed survey (submersible)	12 days
Conduct vessel photography (diver)	1 day
Artifact sampling (diver)	2 days
Soil Measurement tests (diver)	1 day
<u>WRECK NO. 2 COMPLETE</u>	
Demobilization	3 days
Total Estimated Working Days	53 days

If it can be shown that the wrecks are free of rigging and lines, then we propose employing a TROV type ROV. In this instance - providing acoustic navigation is still not desirable - the approach and the schedule outlined above will still be followed. The only exception would be to mount all equipment in-water rather than in-hull.

5.0 ALTERNATIVE APPROACHES

The survey, as outlined on previous page, will produce the desired results. However, there are two alternative approaches which can be employed. One of these is, as already mentioned, an ROV. The second is employment of side scan sonar.

5.1 REMOTELY OPERATED VEHICLE

The ROV recommended for this project would be one of the TROV-type vehicles. Since it contains a variable ballasting system, it can vary its buoyancy in the same manner as SEA OTTER. Additionally, its dimensions and payload permit it to carry a PC-785 camera and strobe and the Unigator system, in addition to closed circuit TV. The lake bed survey would be conducted in a manner identical to that described for SEA OTTER.

For wreck photography/TV an approach can be taken which is used by ROV operators to inspect offshore structures. This approach involves attaching a clump or weight to the umbilical cable some 25 to 30 meters from the vehicle. The clump would be of sufficient weight to keep the cable taut. When the vehicle is deployed the surface ship would maintain a position off to the side of the wreck. The umbilical would hang directly downward and the clump would be held at an altitude of 6.5m. From this position the vehicle would work outward from the clump and attempt to stay on, as much as is feasible, the same horizontal plane as the clump. That part of the cable between clump and vehicle would be buoyed to keep it from dragging or entangling with deck components. When a run across the wreck is completed the vehicle would reverse its course and proceed back to the start point. By using the clump the majority of the cable would remain outside of the wreck and thereby reduce fouling potential.

5.2 SIDE SCAN SONAR

Employment of side scan sonar is recommended as an alternative approach to visually and/or optically searching the lake floor area. The approach outlined above is time-consuming and, therefore, expensive. We would recommend employment of a side scan to conduct a sonic search of the area to reveal the presence of any artifacts proud of the bottom. Since the area is flat and level, and, as far as known, relatively featureless, the side scan record should reveal the presence of baseball-sized objects and even less. (The Klein 500kHz side scan distinctly shows objects of 5 to 7.5cm width.)

The design of the survey tracks can be made to obtain 100 percent overlapping coverage on each run to assure complete area coverage. Navigation while towing would be provided by the del Norte transponder system (+3m accuracy). If any objects are located, one of the optical or visual systems can be deployed to make a positive identification. Using a 50m survey line spacing, one area can be surveyed in less than one day. This alternative is strongly recommended since it would reduce the field time substantially.

PRODUCTS

The following products shall be delivered to the contracting officer within two weeks after termination of the field work, or as soon thereafter as feasible:

- 1) Video tapes (originals) of the lake floor survey tracks annotated with beginning and end position of each tape on the survey grid and with voice/ audio observations of depth/time and other critical data recorded on the tape at one minute intervals or at shorter intervals if necessary.
- 2) Video tapes (originals) of the wrecks annotated with beginning and end of tracks over the vessel.
- 3) Negatives and contact prints of all 70mm photography taken over the vessel. Each exposure will be annotated with time of day and frame number.
- 4) Original transparencies of all 35mm photography taken from within the submersible annotated with date/time and location of the survey grid.
- 5) Log sheet of all sediment bearing strength measurements and schematic showing measurement locations.
- 6) Artifacts collected will be turned over to the on site contracting representative as they are brought to the surface.
- 7) Daily field logs of the operation (topside and underwater) with pertinent observations.
- 8) Chart showing survey track locations, location of sampling positions and location of objects of interest.

7.0 PROJECT ORGANIZATION

The following is a breakdown of the field organization. A total of 11 personnel are seen as required to conduct this project. They are as follows:

PROJECT MANAGER

Submersible Crew

Pilot
Observer
Electronic Technicians
(2)
Photographic Consultant
(part-time)

Diving Crew

Dive Supervisor
Diver
Bell Tender
Surface Tender
Standby Diver

The work schedule is predicated on a 12 hour working day. If a 24 hour working day is desired, then the number of personnel will increase by at least 50 percent. While a 24 hour continuous operation is well within the capability of Can Dive, it is not recommended. It is anticipated that there will be numerous occasions during this project where data will be revealed which may require modifying the program as planned. In the same vein, information will be collected which will require deliberative efforts on the part of the on site contracting representative. Under a 24 hour daily working schedule an overall urgency pervades the work effort. Under these conditions a decision may be made which might have been made differently if there was time for more thoughtful consideration. An eight hour dive mission (which, in reality, amounts to a 10-12 hour day) permits a more deliberative and less urgent schedule for decision making.

Project Manager - will be responsible for the conduct of the entire at-sea phase. This includes equipment and vehicle operation and scheduling of vehicle/diver deployment. The Project Manager and the submersible observer will share responsibilities for diving in SEA OTTER. The Manager will also act as primary Liaison between the operating crew and the on-site contracting representative. He will also be responsible for notifying the cognizant authorities regarding submersible and diving operations in light of safety and rescue.

Submersible Observer - will share diving responsibilities in the submersible with the Project Manager. Will also assist in maintaining logs of all TV/photographic tapes and film and in construction of post-dive track charts.

Submersible Chief Pilot - responsible for all piloting, upkeep and safety features/procedures of the submersible. Will assure that proper pre- and post-dive checks are completed and that the submersible is in a safe diving condition. When underwater, he will take directions from the observer regarding courses and operation of instruments.

Electronic Technicians - responsible for conducting routine maintenance and repair of the submersible. One of these individuals may be a qualified submersible pilot and will alternate, when necessary, with the Chief Pilot in operating the vehicle.

Diving Supervisor - responsible for equipment safety aspects, equipment condition and diver deployment scheduling.

*Diver - stationed in the diving bell. Receives work tasks before descending and works under direction of the Diving Supervisor.

Standby Diver - stationed topside and ready to assist the diver under routine or emergency conditions.

Bell Tender - accompanies the diver inside the bell and assists him wherever possible to conduct his job.

Surface Tender - works under direction of the Diving Supervisor to assure that all surface equipment and lines are operated safely and expeditiously.

In the event that use of an ROV is considered feasible, then the submersible crew will be replaced by the same number of operating personnel for the ROV. The Submersible Observer would then conduct his observations and photography in front of a TV monitor, rather than inside the submersible hull.

*The roles of Diver, Standby Diver, Bell Tender and Surface Tender are all interchangeable.

8.0 COST STRUCTURE

8.1 The cost structure that Can-Dive proposes to utilize on this project is a lump sum mobilization and demobilization with a daily charge for services upon completion of the mobilization stage. This type of arrangement will allow daily flexibility of the project in that changes could be made to the objectives as the on-site contractor representative sees fit. Daily job sheets will be signed at the end of each day in order that the client is fully aware of all charges to be applied to that day's operation.

8.2 HOURS OF OPERATION

As mentioned in the body of the proposal, this project is based on a 12 hour day, with up to 8 hours diving missions. In reality, any 8 hour day offshore stretches itself into 12 hours or longer.

Standby rates are mentioned in the section "Equipment Provided". Standby conditions will apply to situations beyond our control (ie, weather, scheduling, in transit to site, etc.)

"Down-time" rates, as it applies to "Equipment Provided", will be negotiable between Can-Dive Project Manager and the contracting representative. This rate would apply to equipment that has broken down and has not been repaired within a reasonable period of time, or in situations where the contracting representative and the Can-Dive representative have determined that this rate should apply.

Operations will commence mid-summer (August - September) and be conducted on a 7 day per week basis.

8.3 TRAVEL, ACCOMMODATION, MEALS

Travel, accommodation, meals will be charged to our documented cost plus 15%. Since there is food and boarding facilities for 9 people offshore, charges will be \$20.00/man/day. It is anticipated that crew members will share cooking duties. If this is not the case, then a cook could be acquired at our cost plus 15%.

8.4 EQUIPMENT TO BE SUPPLIED BY CAN-DIVE (at Client's discretion)

1	-	Sea Otter Submersible with crew	----	\$2250.00	day
		Standby Charge	-----	1200.00	day

1	-	Bell diving system, complete -----	\$1500.00 day
		(No charge for standby)	
1	-	UDATS TV SYSTEM with 900m cable,	
		U.T.R. -----	300.00 day
		Standby Charge -----	100.00 day
1	-	PC-785 70mm still camera with strobe--	200.00 day
		Standby charge -----	80.00 day
1	-	PC-775 70mm hand held camera with	
		strobe -----	200.00 day
		Standby Rate -----	80.00 day
1	-	Hassalblad in underwater housing	
		with strobe -----	200.00 day
		Standby Rate -----	80.00 day
1	-	Nihon F2 35mm camera motor drive with	
		ocean-eye housing and strobe -----	150.00 day
		Standby charge -----	60.00 day
1	-	Nihonos camera with strobe -----	80.00 day
		Standby charge -----	20.00 day

Rates for any additional equipment required by contractor can be supplied on request.

Alternative equipment rates as per appendix.

8.4.1 PERSONNEL TO BE SUPPLIED

Project Manager -----	\$ 300.00 day
Photo Consultant (as required)-----	300.00 day
Project Consultant (as required) -----	400.00 day

Dive Crew

1	-	diver supervisor -----	325.00 day
		Standby rate -----	175.00 day
4	-	divers/technicians -----	275.00 day/ each
		Standby rate -----	135.00 day each

Dive bonus (depth pay)----- \$1.00/ft. past 100'
per diver for every diver making the dive.

Technicians (as required by contracting \$ 250.00 day/
representative) ----- each

On deck labour (as required)----- 100.00 day/
each

(The dive crew can double as deck crew or labour as
required. In this case their standby rate would
apply.

8.4.2 RENTALS/LEASE (Third party charge)

Any rentals or lease items will be regarded as a third
party charge.

All third services contracted for by Can-Dive
Oceaneering on behalf of the client will be charged for
at our cost plus fifteen percent (15%). This charge
is to compensate us for cost of management and
administrative time involved in the hiring and
reimbursement of these services. Under no
circumstances does Can-Dive Oceaneering assume
responsibility for the adequacy of third party services
and in particular, the performance of their personnel
and equipment..

Any of these third party services and/or materials can
be supplied either directly by the contracting
representative or by any agent directed by him (i.e.
surface support vessels supplied by other source such
as government vessel, generators, etc.)

Third party items include:

1	-	Surface Support vessels ("Johnny B" - 100' x 25')	
		complete with 38' work tug -----	\$2800.00/day
		Standby rate -----	1867.00/day
1	-	10 KW VAC generator (est) -----	400.00/month
3	-	Floodlights (est) -----	450.00 ea/ month
1	-	400 amp welding machine -----(est)	175.00/month
1	-	deck winch (5 ton) -----(est)	210.00/month

- Photo Processing
- Photographic materials
- Courier service (if required)
- Geotechnical services (for soil sample) analysis

8.4.3 CONSUMABLE MATERIALS

All consumable materials will be charged at our documented cost plus 15%.

Consumable materials are to include:

divers HeO₂ gas mixtures
 O₂
 fuel
 greases, lubricants
 cleaning agents
 batteries
 water
 pingers (approx. \$400.00 ea)

8.4.4 CONSTRUCTION OF SPECIAL TOOLS/DEVICES

Fabrication of any special devices (such as soil samples or pressure containers) as required by the contracting representative, will be charged at our labour and materials cost.

8.4.5 INSURANCE

Can-Dive Services Ltd. is fully insured (public liability in excess of \$3,000,000.00) and in good standing with the Workmans Compensation Board. Proof of coverage furnished as request.

8.4.6 MOBILIZATION/DEMOBILIZATION: SEA OTTER/BELL SYSTEM

Complete mobilization, shipping installation of Sea Otter and Bell-Diving System, with crew, on vessel "Johnny-B". Includes labour, materials etc. More detailed break-down available on request. ----- \$53,280.00

Demob: Sea Otter - Bell ----- 19,000.00

Pre site survey & installation of marker
buoys at wreck site ----- \$ 5,750.00
(This cost could be eliminated if Govt.
vessels positioned small marker buoys)

8.4.6.1 MOBILIZATION OF VESSEL TO SITE

Mobilization of vessel to site, installing anchor
and allowing for one site change ----- 9,100.00

8.4.6.2 ALTERNATIVE SYSTEM MOBILIZATION

Should our alternative system be chosen, mobilization
would be as per appendix.

8.4.7 ARBITRATION

Should arbitration be necessary, an arbitrator from the
Association of Professional Engineers of Ontario will
be considered.

8.4.8 REPORT

Reports can be compiled at a charge of \$200.00 man/day
plus our cost plus 15% on any special materials required
or specified by the contracting representative.

REFERENCES CITED

- (1) Bass, G.F. and Rosencrantz, D.M. 1968 A Diversified Program for the study of Shallow Water Searching and Mapping Techniques. The University Museum, University of Pennsylvania, Phila., PA.
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- (3) Childress, F.; Watts, G.P.; Cook, R.W.; and Slama, C.C. 1980 Preliminary Report: Stereo Photography and Artifact Retrieval 16 July - 2 August 1977 Monitor Marine Sanctuary.
- (4) Rebikoff, D.I. 1967 The case for unmanned underwater systems. Sea Frontiers, International Oceanographic Foundation, Miami, Fl. p. 130 - 136.
- (5) Roe, J.T. and Sandilands, R.G. 1975 TROV Operations 1975 Test Report. Canadian Center for Inland Waters, Burlington, Ont., 7 p.
- (6) Busby Associates Inc. 1979 Remotely Operated Vehicles. Government Printing Office, Washington, D.C. Stock Number 003-017-00465-1, 150 pages with appendices.
- (7) Busby, R.F. and Hart, W.E. 1966 Seafloor Navigation for Deep Submergence Vehicles. Journ Inst. Nav., v. 13, n. 2, p. 141-145.



SEA OTTER
(TOP VIEW)

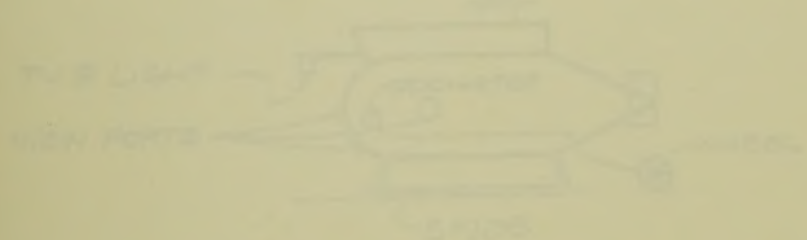
FIGURES

TV COVERAGE



SURVEY TRACKS

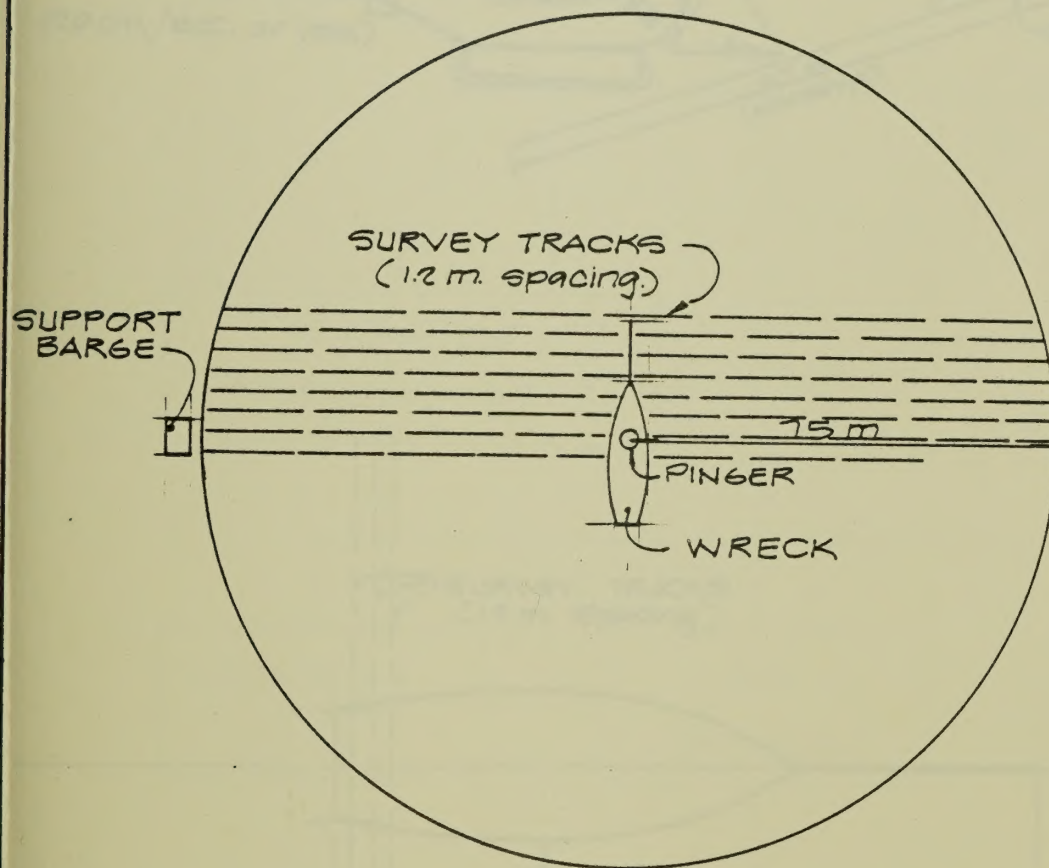
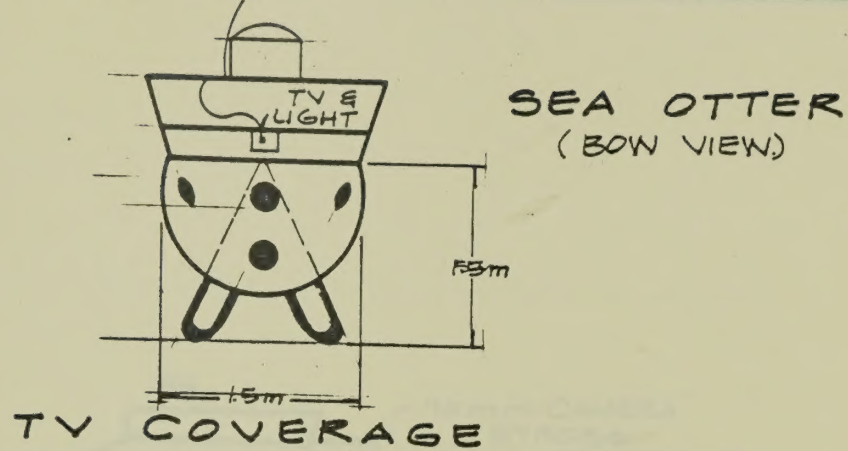
SURFACE UNUSUAL
(TV & LIGHTS)



SEA OTTER
(SIDE VIEW)

FIGURE

LAKE FLOOR SURVEY TECHNIQUE



SURVEY TRACKS.

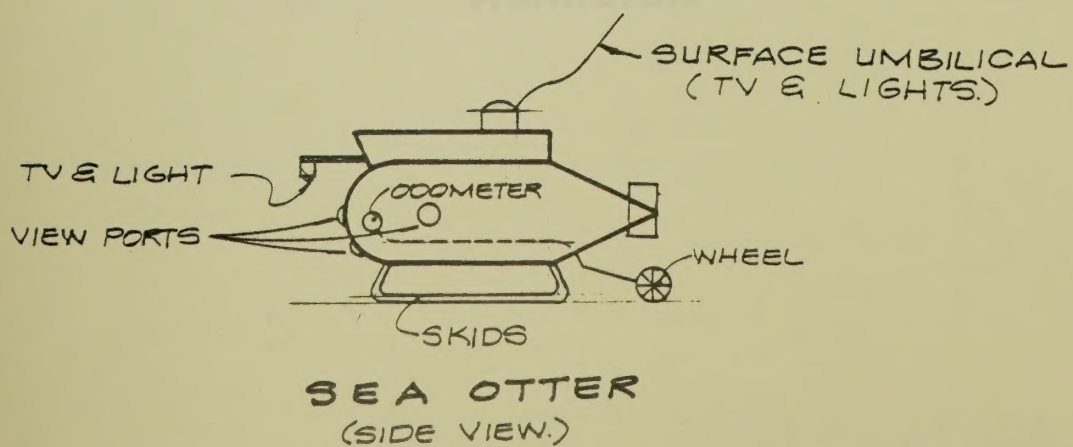


FIGURE 1

LAKE FLOOR SURVEY TECHNIQUE

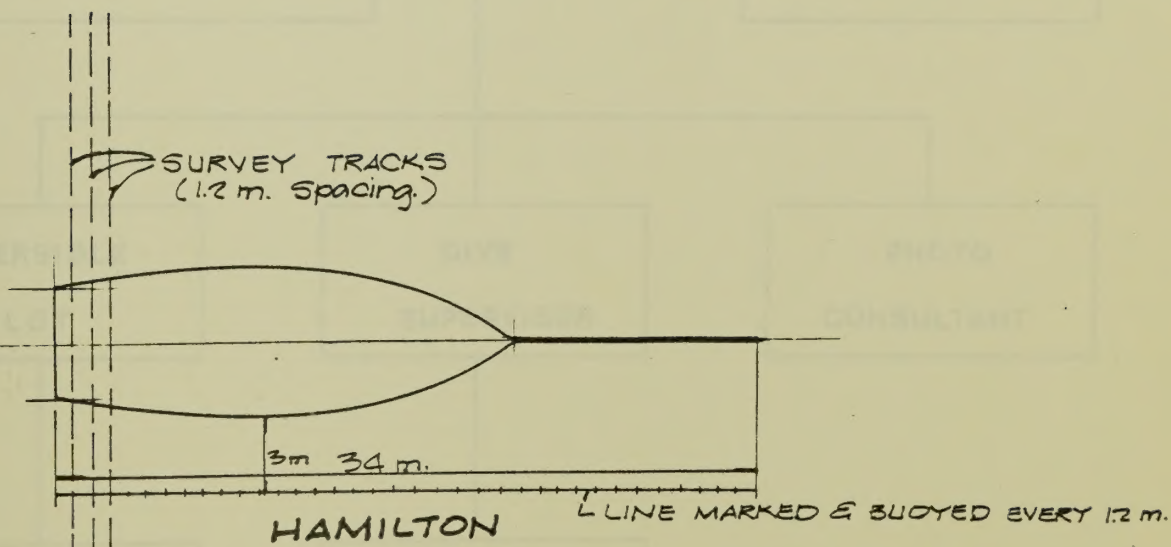
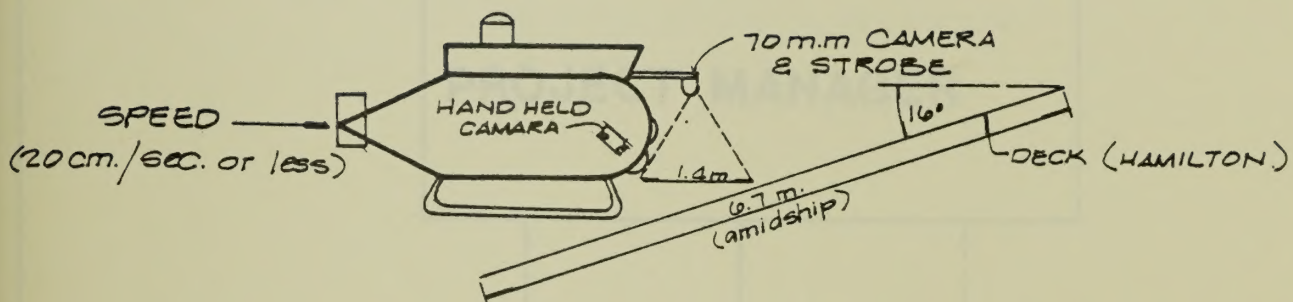
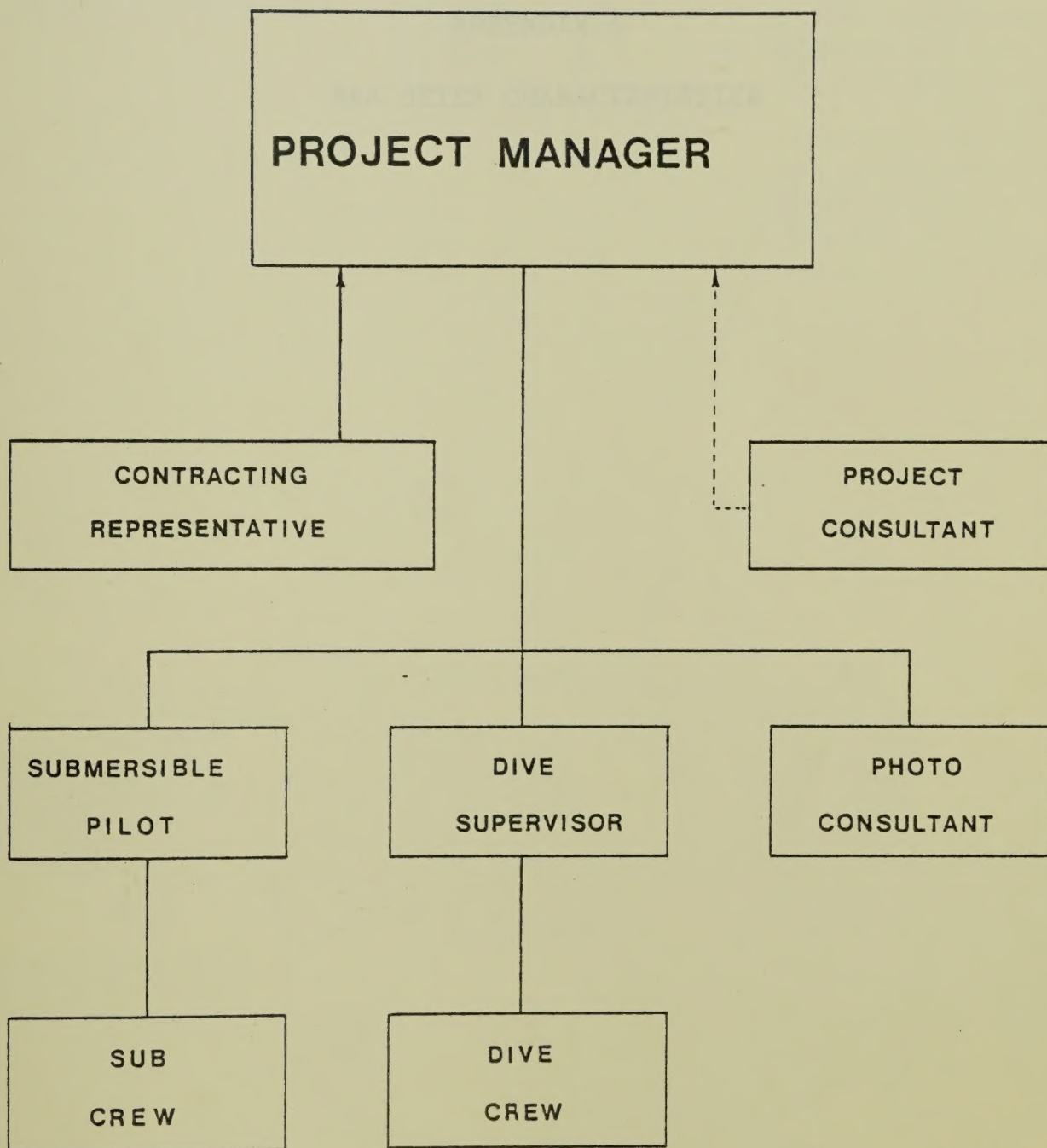


FIG. 2

WRECK SURVEY TECHNIQUE



PROJECT ORGANIZATION

CAN DIVE
OCEANEERING

APPENDIX A

SEA OTTER CHARACTERISTICS

CAN-DIVE SERVICES LTD.

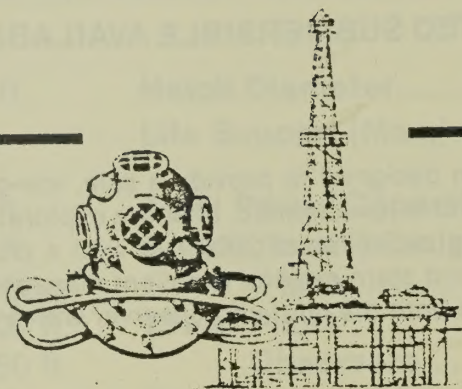
250 EAST ESPLANADE
NORTH VAN COUVER, B.C.
CANADA V7L 1A2

Phone: (604) 584-8137
(604) 587-4913

22-7171 FOREMAN ROAD
MISSISSAUGA, ONTARIO
CANADA L4T 3W9
Phone: (416) 671-1583



CAN DIVE OCEANEERING

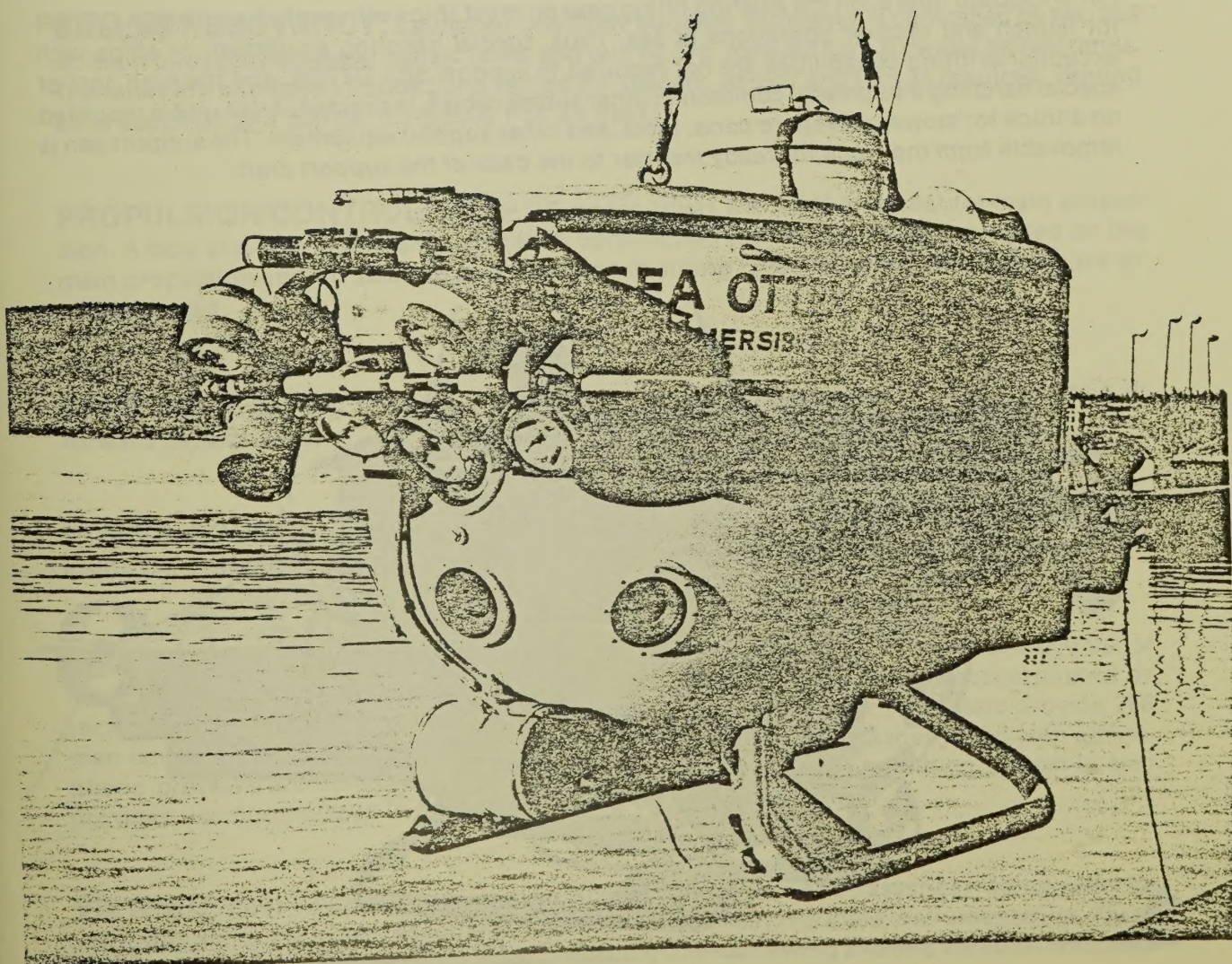


CAN-DIVE SERVICES LTD.

250 EAST ESPLANADE
NORTH VANCOUVER, B.C.
CANADA V7L 1A3

Phone: A.C. (604) 984-9131
(604) 987-4913

22-7171 TORBRAM ROAD
MISSISSAUGA, ONTARIO
CANADA L4T 3W4
Phone: (416) 671-1883



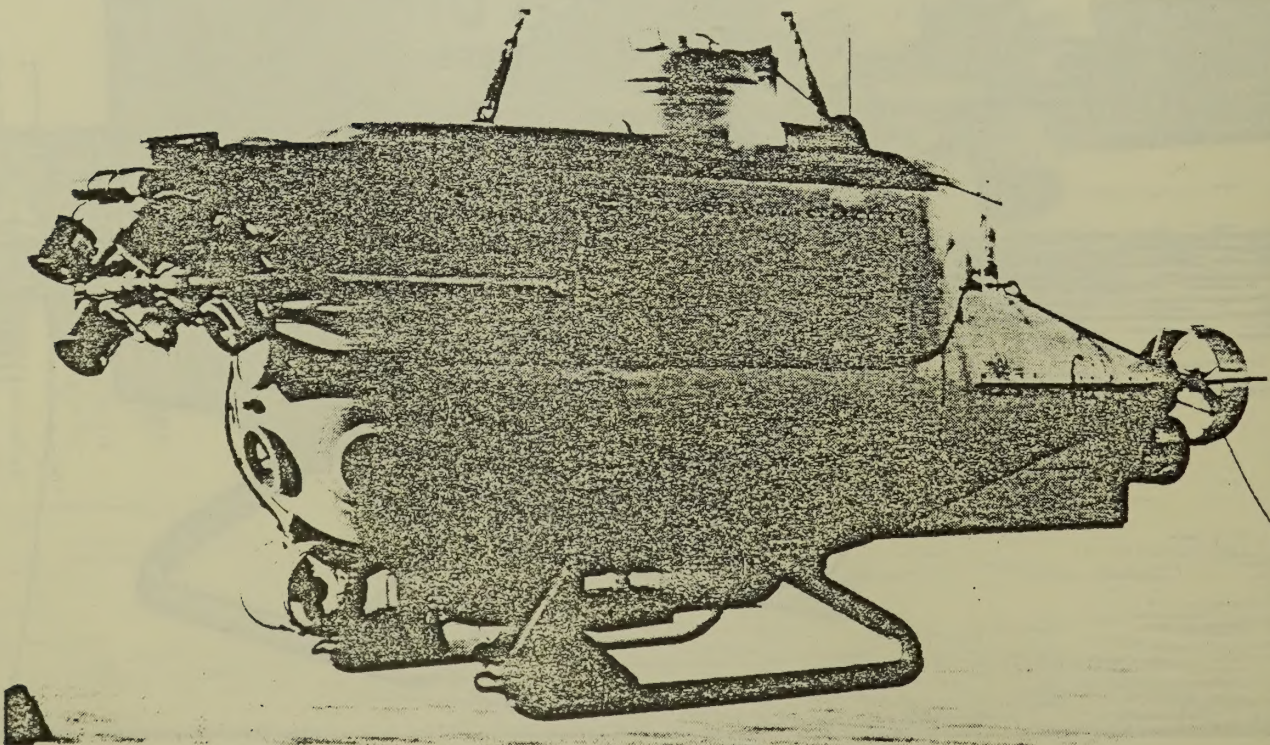
"SEA OTTER":

A WORK-ORIENTED SUBMERSIBLE AVAILABLE FOR LEASE WORLDWIDE

SEA OTTER has been designed to provide a safe, low-cost, lightweight and highly mobile underwater work platform for scientific, offshore exploration, salvage and inspection tasks. It has a depth operating capability of 2000 feet with a cruise speed of two knots. Thrusters mounted at the bow and stern provide excellent maneuvering and hovering characteristics. Ten viewports provide both the pilot and observer with a wide field of vision.

The simplicity of the submersible systems provides a high degree of reliability and minimizes the maintenance and spare parts requirements. A self-contained logistics support package is featured that provides full support to the SEA OTTER in remote areas such as inland lakes reached only via rough logging roads. The lightweight SEA OTTER (6500 lbs.) is transported by boat trailer on land to the desired seaport or lakeside. SEA OTTER and its logistic support package can be air transported throughout the world.

For shipboard operation the existing lifting gear on most ships will readily handle SEA OTTER for launch and recover operations at sea. Thus, special handling equipment or ships with exceptional lifting capabilities are not required to support SEA OTTER, and the high cost of special handling equipment, common to other submersibles, is avoided. A van unit is mounted on a truck for stowage of spare parts, tools, and other support equipment. The support van is removable from the truck for ready transfer to the deck of the support craft.



Length	13.5 ft.	Hatch Diameter	19 in.
Beam	5 ft.	Life Support (Max.)	256 man hrs.
Height	7.2 ft.	Total Power Capacity	13.8 KWH
Draft	5.5 ft.	Speed (knots) Cruise	1 @ 6 hrs.
Weight.....(dry)	3.2 tons	Max.....	3 @ 1.5 hrs.
Operating Depth.....	2,000 ft.	Crew: Pilots	1
Collapse Depth.....	3,650 ft.	Observers	2
Launch Date	1971	Payload	550 lbs.

PRESSURE HULL: Two 0.625 in. thick, section welded, mild steel, hemispheric sections are welded to the ends of a 0.75 in. thick, 57.0 in. long, 48.0 in. wide, mild steel cylinder, with a 0.75 in. thick, 19.0 in. diameter, hatch tower, welded in with doubler plate to the pressure hull.

BALLAST/BUOYANCY: Launched positively buoyant. Buoyancy is controlled by two 250 lb. main buoyancy air/water ballast tanks and two 62.5 lb. forward trim air/water ballast tanks. The tanks are alternately flooded and vented for descent, ascent and trim as required. Venting air is supplied by a 500 cu. ft., @3000 PSI, air flask.

PROPULSION/CONTROL: A 3 HP DC motor drives a 9" x 15" propeller for main propulsion. A bow and stern thruster is utilized in conjunction with a korts nozzle mounted on the main propulsion unit for steering and operation in strong cross currents. All thrusters are air compensated.

TRIM: Bow angle and fine trim are controlled by HP air and water in either the main or forward ballast tanks.

POWER SOURCE: Twelve 2-volt lead acid batteries provide 13.8 KWH. They are located inside the pressure hull and are equipped with palladium catalyzers to eliminate hydrogen.

LIFE SUPPORT: Two 40 cu. ft. tanks at 2,000 psi and two 80 cu. ft. tanks at 3,000 psi of medical grade oxygen supply the life support system. Scrubbing of CO₂ is accomplished by recirculating through a 6.4 pound lithium hydroxide cannister. Four cannisters provide 256 man hours of available life support on each dive. CO₂ and O₂ percentages along with atmospheric pressure are constantly monitored. A back up emergency breathing system is also provided via mouthpieces in case of fire, power failure or flooding.

VIEWING: Four viewports are provided forward for the pilot and passenger, along with two viewports along the side to accommodate reading externally mounted instrumentation. Three viewports are located in the hatch tower, providing 270° of viewing and one viewport is located in the hatch, providing visibility toward the surface.

OPERATING/SCIENTIFIC EQUIPMENT: Three underwater communications systems are provided: Two 27 KHZ primary units and a 10 KHZ secondary. Directional receivers for communications, homing and tracking on both frequencies are also available. A 23 channel C.B. and a 12 channel VHF-FM radio is used for surface communications and DF location. 27 KHZ and 10 KHZ pingers plus a transponder system are installed for location, tracking and diver/submersible rendezvous operations. Internal gyro compass, external wet compass, tri-beam looking echo sounder, depth, temp and pressure gauges are installed for recording and navigation. Data recording equipment includes 35 mm, 70 mm and polaroid cameras, 16 mm cine with 400 ft. film capacity, audio and video recording systems. Six lights including flood and spots, totalling 51,000 lumens are used for search and photographic missions.

MANIPULATOR: The NAR "Beaver" MKI Manipulator gives all the degrees of freedom of the human arm and hand, plus 360° rotation at the wrist and a wrist extension. Additional tools are available and can be provided on the manipulator for specific tasks. An "A" frame which is hydraulically controlled is also provided and is utilized as an attachment point for core samples, cable cutters, collection basket and many other tasks and applications, as required.

In addition a sled containing batteries, hydraulics and pneumatic systems can be mounted on the bottom of the Sea Otter for cutting large diameter wire rope. This unit comes equipped with its own 14 ft. telescopic boom and cutter head.

SAFETY FEATURES: A 200 lb. mechanically releasable, emergency ascent weight and a releasable buoy and messenger line be released by the pilot through a thru-hull penetrator. In the event that the pilot is incapacitated the buoy release is automatic. The messenger line is used to send down a self-locking clamp and lift line. Thus, the submersible can be retrieved even if flooded. Eight hours of emergency breathing air is also provided.

SURFACE/SHORE SUPPORT: Can be transported by aircraft, ship, truck or trailer. Submersible is normally on a trailer and can be launched from a small boat launching ramp. It can be towed at 4 to 5 knots and tows completely submerged.

SEA OTTER is available for long or short-term lease. Because of its design simplicity and low maintenance operation, the complete submersible, crew and support system can be mobilized immediately. Day, week or monthly rates do not vary greatly. However, for long-term leases, rates for operational days, stand-by or periods of maintenance can be arranged. Operational experience to date indicates that SEA OTTER's multi-drive capability and short turn-around cycle provide the user with more underwater work time. The small crew size, specially designed support system and low maintenance requirements of SEA OTTER have proven that the lease rates for CAN-DIVE'S submersible system are very competitive.

"700" SERIES PHOTOGRAPHIC EQUIPMENT

APPENDIX B

Camera/TV Specifications

PERFORMANCE

High Performance. The new Photographic Equipment features the highest in image clarity, contrast, and resolution. The new lens, shutter, and viewfinder are all designed to provide the best possible performance. The new lens is designed to provide the best possible performance. The new shutter is designed to provide the best possible performance. The new viewfinder is designed to provide the best possible performance.

Standard Features. The new Photographic Equipment features standard features such as a built-in flash, a built-in viewfinder, and a built-in shutter. The new lens is designed to provide the best possible performance. The new shutter is designed to provide the best possible performance. The new viewfinder is designed to provide the best possible performance.

DESIGN

Compact Design. The new Photographic Equipment features a compact design that is easy to carry and use. The new lens is designed to provide the best possible performance. The new shutter is designed to provide the best possible performance. The new viewfinder is designed to provide the best possible performance.

VIDEO CAMERA

The new Video Camera is designed to provide the best possible performance. The new lens is designed to provide the best possible performance. The new shutter is designed to provide the best possible performance. The new viewfinder is designed to provide the best possible performance.

CAMERA MECHANISM

The new Camera Mechanism is designed to provide the best possible performance. The new lens is designed to provide the best possible performance. The new shutter is designed to provide the best possible performance. The new viewfinder is designed to provide the best possible performance.

DATA CHARTER

The new Data Charter is designed to provide the best possible performance. The new lens is designed to provide the best possible performance. The new shutter is designed to provide the best possible performance. The new viewfinder is designed to provide the best possible performance.

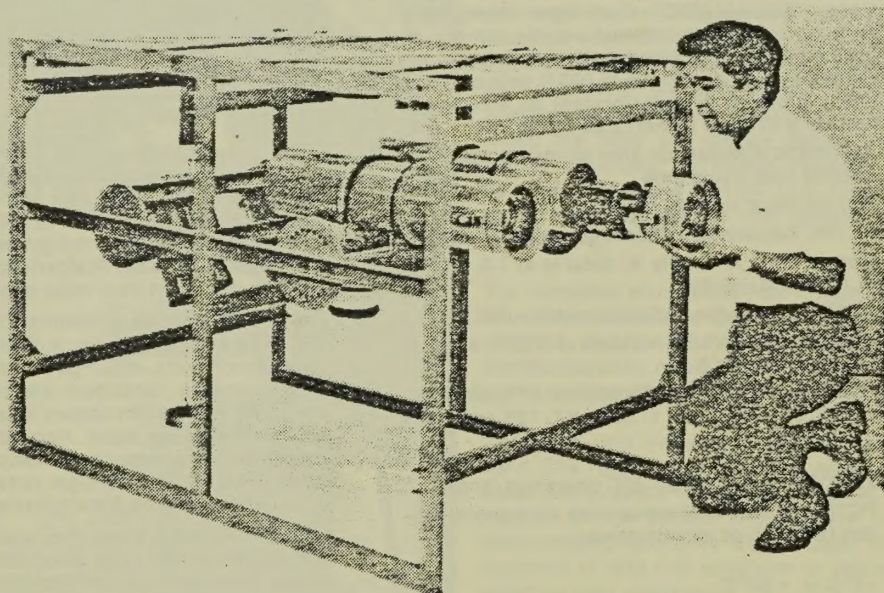
The new Data Charter is designed to provide the best possible performance. The new lens is designed to provide the best possible performance. The new shutter is designed to provide the best possible performance. The new viewfinder is designed to provide the best possible performance.

The new Data Charter is designed to provide the best possible performance. The new lens is designed to provide the best possible performance. The new shutter is designed to provide the best possible performance. The new viewfinder is designed to provide the best possible performance.

®

"700" SERIES PHOTOGRAPHIC EQUIPMENT

SUTTER & COMPANY, INC.
P.O. Box 757, Vienna, Va. 2218
703-938-0505



PERFORMANCE

Hydro Products' "700" series Photographic Equipment provides the ultimate in deep ocean photography. The large format, 70mm cameras will take up to 400 exposures on one loading and can automatically provide the user with frame number, time of day, and a data card adjacent to each exposure, all recorded at the same time as the subject.

Standard features of all cameras include "Aquamatic" cartridge loading, shutter, iris, and focus controls, and a fully corrected, water-contact lens system. The precision film advance mechanism is electronically controlled to assure perfect synchronization on each exposure. Companion strobe lights can be recycled in less than 5 seconds at energy outputs up to 200 wattseconds.

DESIGN

Unique design features available with the "700" line of photographic equipment are the result of over fifteen years experience in supplying 70mm underwater cameras. The Hydro designed front element for the Leitz lens system alone is the result of more than two years research and testing. Over 1,000 pressure tests to pressures greater than 10,000 psi were conducted during the development of this high pressure front lens element.

PC785 CAMERA

The PC785 camera is normally used on a frame or vehicle where remote control of all camera functions or self-contained automatic operation is desired. An optional feature on the 785 includes remote servo control of iris and focus from a vehicle or the surface.

CAMERA MECHANISM

Both the PC705 and PC785 cameras contain the same basic camera mechanism shown above. Housing and options are changed depending on particular requirements. The camera mechanism removes from the front so that the heavy housing can remain on a vehicle or frame and doesn't have to be handled on the deck of a rolling ship.

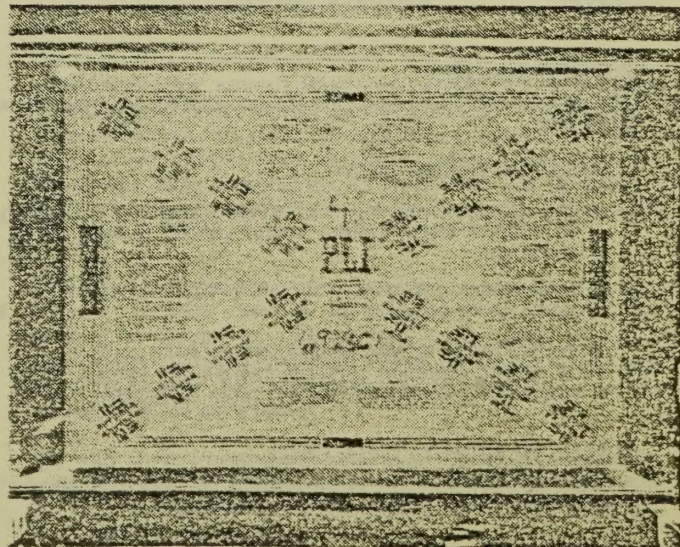
The removable mechanism includes the Leitz water contact lens system, shutter, iris, and focus controls, and the unique AQUAMATIC film cartridge, and weighs less than 20 lbs.

DATA CHAMBER

A modular data chamber is available as an option on all "700" series cameras. It provides frame number, time of day, and a small data card as shown below. The data appears adjacent to its corresponding photograph eliminating the need to correlate data several frames away from its associated picture.

The data is presented in a space between exposures allowing a full 400 exposures per 100 ft. roll of film. Data is exposed on the emulsion side of the film allowing use of color films with opaque backings.

The data chamber is a plug-in unit with its own lens and lighting system. An ASA switch on the camera mechanism adjusts the data chamber lighting system for proper exposures at various film speeds.



Resolution chart photographed through 4 feet of water with the water-contact lens system. Note complete lack of distortion.

PC705 AND PC785 CAMERAS

OPTICAL

LENS:	Water contact 43.7 mm, f/2.8
VIEWING ANGLE:	67° Diagonal in water 50° Horizontal and Vertical
DISTORTION AND RESOLUTION FROM CENTER AXIS OF LENS SYSTEM	0° —0 distortion, 45 lines/mm resolution 7.5° —0 distortion, 40 lines/mm resolution 15° —0.04% distortion, 36 lines/mm resolution 23.5° —0.4% distortion, 32 lines/mm resolution 30° —1.0% distortion, 24 lines/mm resolution

PHOTOGRAPHIC

FILM:	Uses "AQUAMATIC" Cartridge. Completely light-tight and easily inserted into the camera, allowing instant film reloading by simple cartridge replacement. Capacity up to 100 ft. rolls of 70mm film (perforated or unperforated) on $\approx$ 10 spool. Format is 57mm x 57mm (2.25 x 2.25 in.).
FILM ADVANCE:	Automatic in sequence after shutter closes; 4 second max. cycle time.
EXPOSURES:	400 minimum to a 100 ft. roll.
FOCUS:	PC785: Adjustable by Servo control.—RC only Range 1.5 ft. to infinity w/ detents at 1.5, 2, 3, 4, 6, 10 ft. and infinity.
APERTURE:	PC785: Adjustable by Servo control.—RC only Range f/2.8 to f/16 w/ detents at f/2.8 f/4, f/5.6, f/8, f/11 and f/16.
SHUTTER:	Range 1 second to 1/125 second w/ detents at 1, 1/2, 1/5, 1/10, 1/25, 1/50 and 1/125 second.

GENERAL

POWER:	28 VDC nominal, 22-32 VDC operating range. PC785 Camera is powered from an external battery (BP-708) or vehicle power.
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TEMPERATURE

RANGE:	-5°C to +50°C.
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DATA CHAMBER:

Optional plug-in data chamber provides time of day, frame number, and data card adjacent to associated exposure.

MECHANICAL

WEIGHT:	PC785: 75 lbs. in air, 33 lbs. in water (maximum).
HOUSING MATERIAL:	Aluminum, hard-anodized, epoxy painted.
CONNECTOR:	Waterproof, provides power and flash synchronization; and remote servo controls on PC785.
OPERATING DEPTH:	6,100 m (20,000 ft.).
CERTIFICATION DEPTH:	9,200 m (30,000 ft.).

ACCESSORIES

Accessories and spare parts kits are available for all "700" Series equipment.

Accessory Description

• Photographic system frame, provides mounting for single or stereo system, bottom contact switch, and pinger	MODEL NO. OF-700
• Bottom contact switch, redundant switch mechanism for maximum reliability	BCS-700
• Rechargeable nickel-cadmium battery pack for remote operation of PC785 camera with servo controls and companion strobe, depth 20,000 feet	BP-708

REMOTE SERVO CONTROL

An optional feature on the PC785 camera includes remote servo control of iris and focus, from a vehicle or the surface.

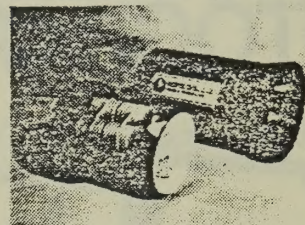


- Camera "actuate"
- Iris control
- Focus control
- Frame counter

Optional Remote Servo Control

STROBE LIGHTS

Companion strobe light for the "700" Series camera is the PF730.



The strobe has adjustable energy outputs of 200 wattseconds maximum with a repetition rate of one flash every five seconds. Flash power is adjustable from 50 to 200 wattseconds. The parabolic reflector design gives a uniform light pattern not found with any other type of underwater strobe. The perfectly flat light pattern is without the hot spots so prevalent from most strobes.

The PF730 operates at nominal 28 VDC over a voltage range 22 to 32 VDC. The strobe includes a charge sensing circuit which automatically disconnects input power to the strobe electronics after the energy storage capacitors are charged. This circuit keeps current drain from the system battery at less than 30 mA except when a flash exposure has been made. Also included is a unique input voltage sensing circuit to automatically disconnect input power from the strobe electronics when the system voltage drops below 20 VDC to prevent over-discharging the system battery pack.

Strobe housings are designed with a spherical front port similar to the camera lens giving a low drag profile and eliminating reflector maintenance. The depth capability of the PF730 is 20,000 ft. These units are also certified to 50% beyond their operating depth.

PF730 STROBE

ELECTRICAL

INPUT POWER:	28 VDC nominal (22 to 32 VDC operating range).
PEAK CURRENT:	14 amperes during recharging cycle.
OPERATING MODE:	Standard "X" Sync or "Slave" operation.
FLASH TUBE INPUT:	Adjustable 50-200 wattseconds.
FLASH REPETITION RATE:	Once every 5 seconds minimum.

MECHANICAL

WEIGHT:	PF730: 25 lbs. in air, 10 lbs. in water (maximum).
HOUSING MATERIAL:	Aluminum, hard-anodized, epoxy painted.
CONNECTOR:	Waterproof, self purging.
REFLECTOR:	Hydro Products unique parabolic reflector design located behind spherical front port to reduce drag providing a uniform light pattern with no hot spots.

ENVIRONMENTAL

OPERATING DEPTH:	PF730: 6,100 m (20,000 ft.).
TEMPERATURE RANGE:	-10°C to +50°C

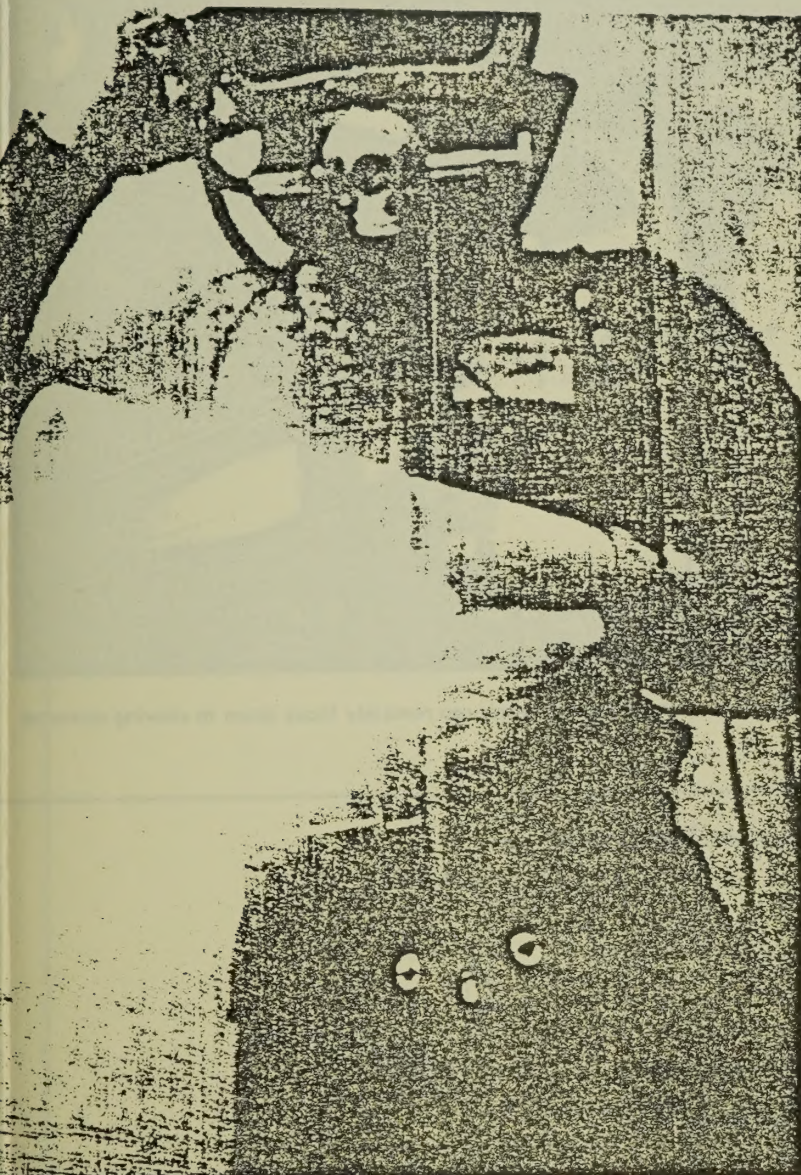
Installation drawings are available for all "700" Series Photographic equipment upon request.



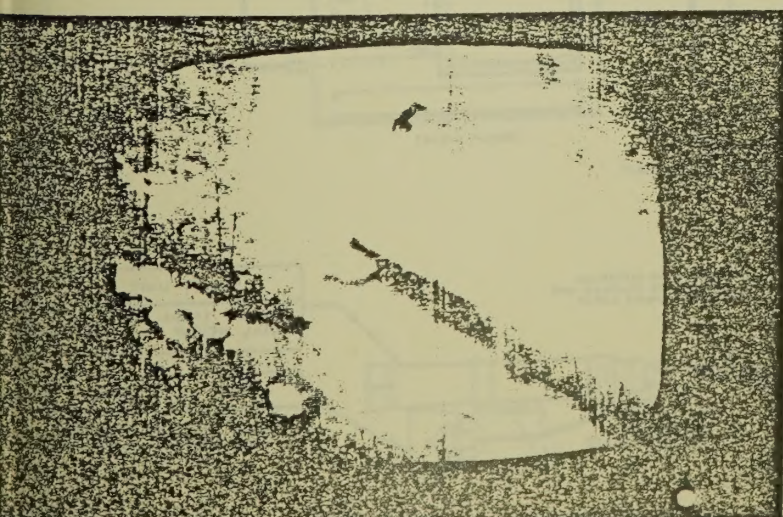
Hydro Products
A TETRA TECH COMPANY

UNDERWATER DAMAGE ASSESSMENT TELEVISION SYSTEM

CAN-DIVE OCEANEERING



The Diver Unit of the UDATS system consists of Hydro Products' Model TC-125 Miniature Television Camera and Model LT-8 Diver Held Thallium Iodide Light.



Actual photograph from a video tape replay shows a propeller shaft on a barge with suspected damage at Albina Shipbuilding, Portland, Oregon.

Although underwater television has been in use for quite some time, it has recently come into its own as a diver's tool for ship hull inspection and damage assessment due to the development of a simple, rugged closed-circuit audio/video system. Surface personnel can now inspect and assess damage with the diver and make permanent video tape records. The surface control station presents a television picture from a miniature underwater camera unit carried by the diver. Two-way telephone quality communications is also provided so the surface operator can direct the diver and discuss damage with him first hand. The system developed by Hydro Products is shown above. It was developed originally for the U.S. Navy for ship hull and sonar dome inspection and is now gaining wide use in commercial applications.

The complete diver inspection system is as simple to set up and operate as a portable television set. It includes a surface unit, recorder, diver unit (shown on top of the surface unit), and a communications mask. Audio and video signals are transmitted to the surface via a small 1/2" diameter cable.

The diver unit includes a self-contained television camera and light. The rugged, compact unit weighs less than five pounds in water and is easily handled by the diver. One of the most unique aspects of the system is its ability to see in low-light level environments and dirty water. Good video pictures have been obtained of ship hull condition or damage with divers reporting only one foot visibility!

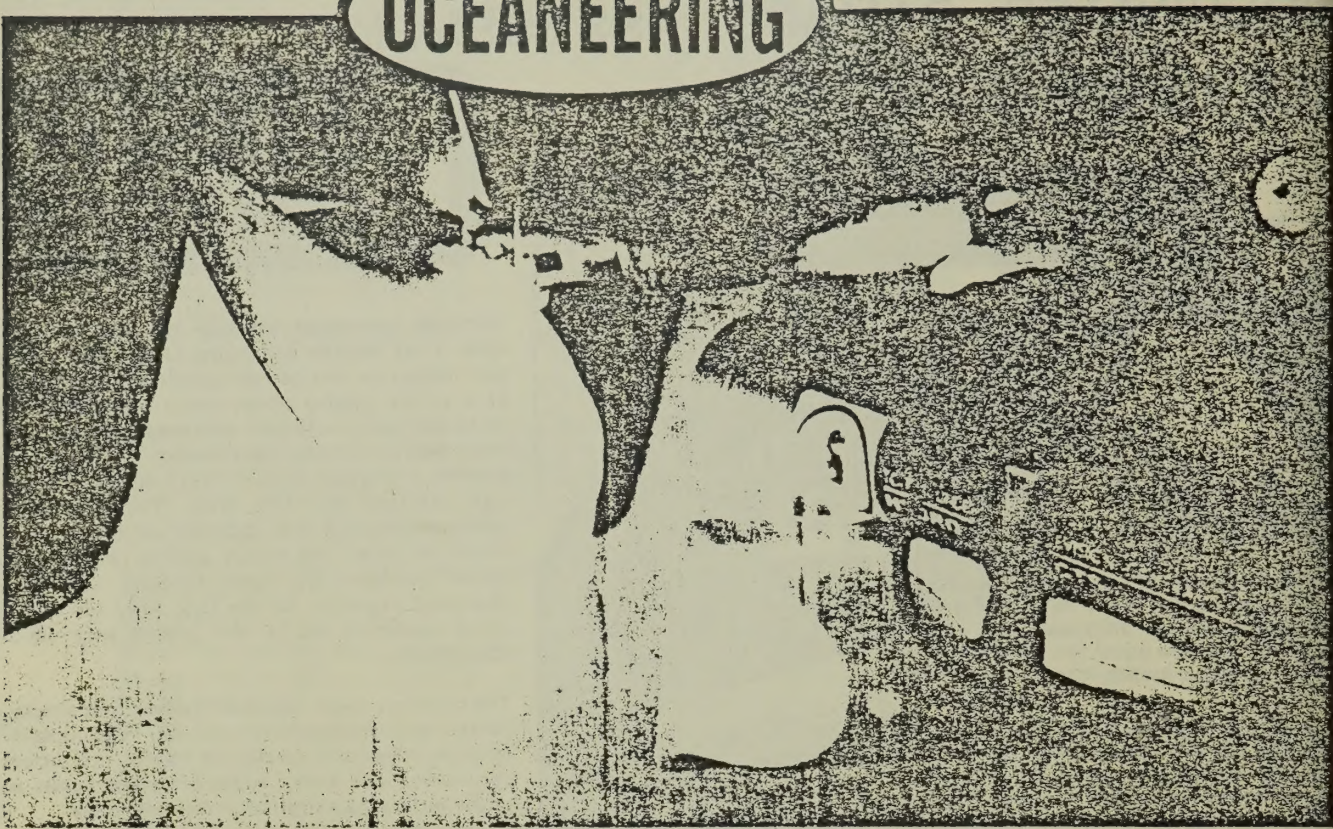
The rugged surface unit includes all controls for system operation . . . television monitor, remote camera focus control (3 inches to infinity), and direct on-line communications to the diver. Designed for the harsh environment encountered in most underwater inspection tasks, the surface control unit is completely splashproof with all seams and openings rubber-gasketed.

Permanent video and audio records can be made of a complete survey with the recorder included in the system. Instant playback can be accomplished by the flip of a switch and the video/audio recording can be played back in real time, slow motion or stop-action.

The 125 Diver Inspection System has become an invaluable accessory for the sophisticated working diver. It has enhanced his capability beyond simple damage assessment and inspection tasks to include "on-the-spot" engineering evaluation while in direct communication with surface personnel. The permanent audio/video tapes provided by the system can also be used as a "Quality Control" method for ship hull cleaning or underwater repairs.

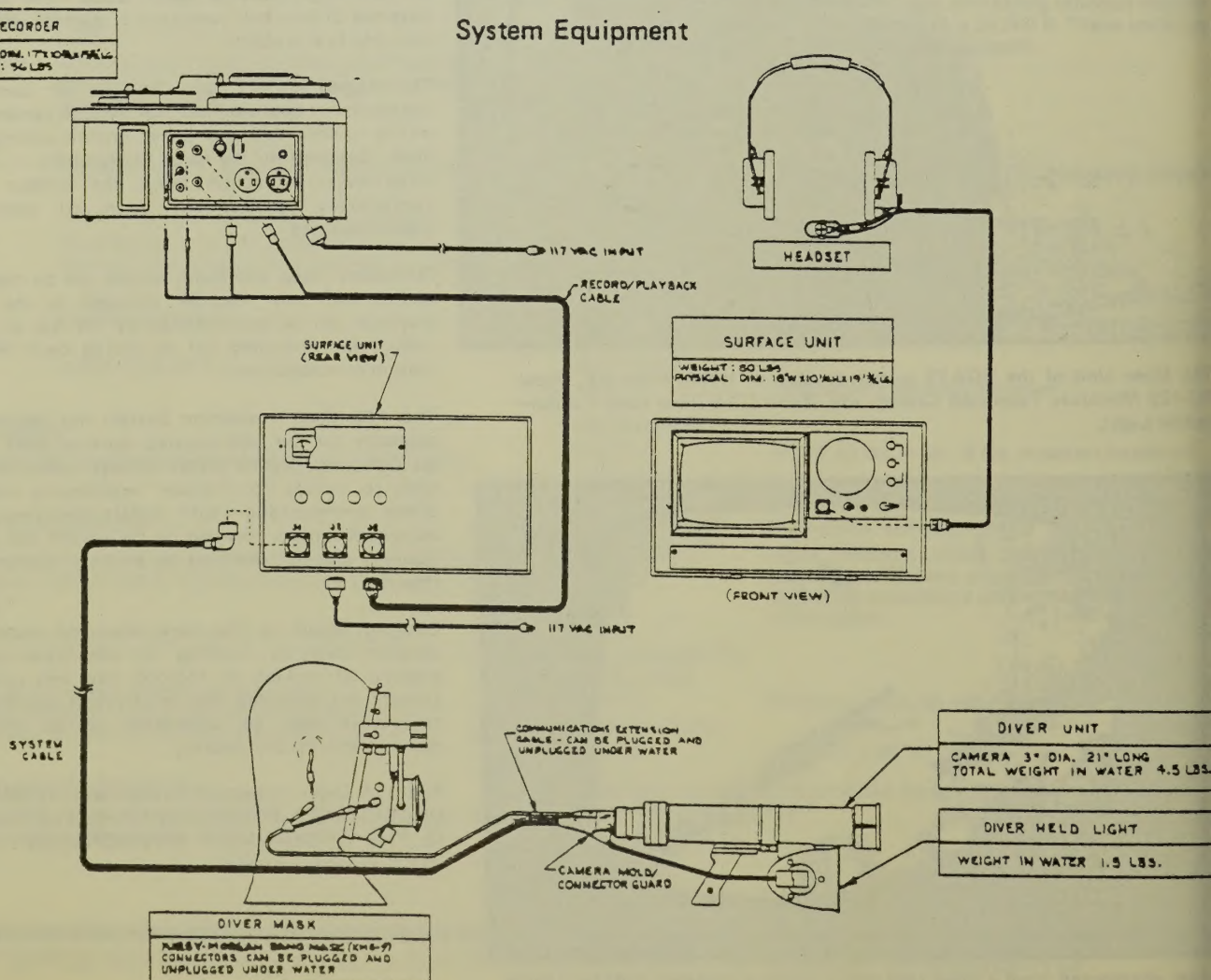
Looking ahead to the time when the supertanker building program outstrips facilities for the repair and routine dry docking of tankers of 150,000 tons and upward, Lloyds of London has indicated that in its future operations, underwater television may be undertaken as an alternative to the requirements for dry docking.

The 125 Diver Inspection System was DESIGNED FOR THE UNDERWATER ENVIRONMENT PEOPLE WHOSE BUSINESS IS THE UNDERWATER ENVIRONMENT . . . one look and you'll see what we mean.



The UDATS system can be used for the closest detail inspections. The surface operator can remotely focus down to viewing distances of 3 inches.

System Equipment



APPENDIX C

Resumes of key personnel are as follows:

PROJECT MANAGER Resumes of Key Personnel

Project Management will be under one of the following individuals: Doug Elmer, P. Eng.
Jim Graham, P. Eng.
Phil Harrison, P. Eng.

PROJECT CONSULTANTS

R. Frank Smith

ENVIRONMENTAL ENGINEER

R. Weidner (alternates: J. Michael Gaudet)

PHOTOGRAPHIC CONSULTANT

R. Weidner (alternates: R. Smith, Joseph Palmer)

Personnel

Resumes of key personnel are as follows:

PROJECT MANAGER :

Project management will be under one of the following individuals: Doug Elsey, P. Eng
Jim English, P.Eng
Phil Nuytten, Pre.

PROJECT CONSULTANT:

R. Frank Busby

SUBMERSIBLE OBSERVER :

P. Mockler (alternate: J. Michael Costin)

PHOTOGRAPHIC CONSULTANT:

P. Mockler (alternates: R. Mason, Joseph Pollis)

RESUME: Douglas R. Elsey, P. Eng.

Born 1946

EDUCATION:

B. Sc. (Eng.) in Ocean Engineering,
Florida Atlantic University, Boca Raton,
Florida, 1972.

Mechanical Engineering Technology,
Ryerson Polytechnical Institute,
Toronto, Ontario

Registered Professional Engineer, Ontario.

EXPERIENCE

1975 - Present - Can-Dive Services Ltd.,
Toronto, Ontario.
Manager, Great Lakes Division.

General and Operations Manager of the Great
Lakes Division of Can-Dive Services. Respon-
sible for all onshore and offshore diving
operations in the Great Lakes, East Coast
and Eastern Canadian Arctic. Underwater design
and engineer for Can-Dive Services.

1970 - Present - J.A. MacInnis Foundation;
Project Engineer for all special underwater
Arctic projects of the foundation.

1973 - 1975 - Department of National Defence.
SOK-1MDP. Project Engineer - Deep Diving Systems.

Project Engineer in charge of project to design
and test a diver heating/diver breathing system
for lock-out submersibles to a depth of 1,000 ft.
(300 m). This system was to operate in the
high Arctic.

1974 - J.A. MacInnis Foundation, on loan to
the Foundation from D.N.D. to co-lead a two
month Arctic underwater expedition. In charge
of all engineering, logistics and scientific
co-ordination. (Arctic IV Expedition).

1972 - 1973 - Arctic Canadian Continental -
Shelf Exploration Services (ACCESS LTD.).

Engineer. Construction and operation of a sub-
mersible capable to operate to 1200 ft. beneath
the Arctic ice. (Company folded due to lack
of contracts). Submersible pilot.

1973 - J.A. MacInnis Foundation. Second in command
of a one month expedition to the High Arctic to
place an underwater habitat beneath the Arctic

ice. (Sub Igloo).

ADDITIONAL
EXPERIENCE
(DIVING)

Six months in Gulf of Mexico as an offshore diving technician for Fluor Ocean Services. Participated in deep diving operations (saturation and bounce diving). (Part of school Engineering co-op work study program). Involved in diving since 1954 - commercially since 1964.

Six months as Life Support Engineer on Canadian undersea habitat "Sublimnos". One of the designers of "Sub Igloo". The first polar under ice station.

PUBLICATIONS:

Have published numerous papers on High Arctic diving operations - available on request. Photo contributions to more than 15 publications on Arctic diving and deep diving operations.

Elsey, D.R., Construction and Evaluation of an Under Ice Polar Station

The Working Diver '74 Symposium Proceedings, Battelle Laboratories, Columbus, Ohio.

Elsey, D.R., "Arctic 111 Expedition: Sub-Igloo Under Ice Station"

Presented at the 5th International Conference on Underwater Education, Toronto, 1973 (Unpublished)

Elsey, D.R., "Operational Problems of Under Ice Navigation"

Presented at the First Symposium on Navigation and Resource Management, Canadian Aeronautics and Space Institute, Ottawa, 1974. (Unpublished).

Elsey, D.R., "Arctic IV Expedition" D.C.I.E.M. Operational Report,

Presented at the Oceans Canada Conference, Toronto, 1974.

Elsey, D.R., "Evaluation of the Drager FGT 1/D and LAR 111 U.B.A."

D.C.I.E.M. Operational Report, 1974.

Elsey, D.R., "Evaluation of the Piel Isothermal Electrically Heated Suit"

D.C.I.E.M. Operational Report, 1973.

Elsey, D.R., "Implications of Diving in Cold Water"

Cold Water Symposium, University of Toronto, Toronto, 1976.

Elsey, D.R., MacInnis, J.B., - "The Search for the HMS Breadalbain"

Third Annual Canadian Deep Diving Symposium, D.C.I.E.M., 1978.

Photo contributions include Popular Mechanics, Enroute Magazine, Sentinel Magazine, The Toronto Sun, The Toronto Globe and Mail, Science Forum Magazine, Weekend Magazine, Ocean Industry, etc.; Cine Photographer from 16mm Film "ARCTIC JIM".

Have lectured extensively to colleges, universities and professional groups on commercial diving techniques, Arctic diving and problems encountered while involved in the hyperbaric environment.

PROFESSIONAL AFFILIATIONS:

Association of Professional Engineers of Ontario.
National Association of Underwater Instructors (Instructor)
Association of Canadian Underwater Councils (Instructor)
Marine Technology Society
Underwater Medical Society

REFERENCES AVAILABLE ON REQUEST

RESUME: James G. English, P. Eng.
Special Projects Engineer
Can-Dive Services Ltd.,
North Vancouver, B.C.

EDUCATION: Graduated in 1971 from the University of
Waterloo with a B.A. Sc. in Mechanical
Engineering.

EXPERIENCE: 1966 - 1971

Worked under the co-op plan for:
an Underwater Research Program in Lake Huron
as Diving Supervisor for the Great Lakes
Institute, University of Toronto and Union
Carbide, Linde Gas Division.

1971 - 1975

Worked as Project Engineer, for the Lora - 1
Habitat Program, Ocean Engineering Group,
Memorial University of Newfoundland and served
as Diving Officer for the Faculty of Engineering.
During this time supervised diving operations for
a number of Master's thesis projects and partici-
pated in and supervised several shallow saturation
dives, including one conducted during the J.A.
MacInnis Foundation Arctic IV expedition, Resolute
1974.

1975

Joined Can-Dive Services Ltd., as Special Projects
Engineer. Duties have included:

development of advanced diver heating equipment for
North Sea lock-out submersible use; equipment
evaluation and testing to 1,000 feet.

Duke University:

development of a helmet for use with electronic
mixed gas breathing apparatus; field operations
concerned with the Jim Atmospheric Diving System;
Project Manager of Jim ADS dive to 900 feet for
Panarctic Oils.

1976

Design and development of air transportable deep
dive system for remote Arctic use - Panarctic Oil/
Drake.

PAST EXPERIENCE

1984 - Present

1978

Consulting to Dept. of National Defence on diving systems; design, engineering and supervision of a variety of marine construction and salvage operations on the west coast; Project Manager of Arms 1 diving operations to 2,800 feet off Nova Scotia - Chevron Oils, 1978;

1979

Operations Manager Arms 1 - Glomar Atlantic Diving Support, Newfoundland/Labrador; and Operations Manager - Trov - S9/Arms 111 - Ben Ocean Lancer Diving Support, Newfoundland/Labrador.

Began diving in 1959 and started working professionally in 1965, with extensive Arctic and cold regions experience. Member of the association of Professional Engineers of British Columbia and past member of the Association of Professional Engineers of Newfoundland; Marine Technology Society; Undersea Medical Society.

RESUME

Phil R. Nuytten

President Can-Dive Services Ltd.

PAST EXPERIENCE

1969 - Present

President and General Manager,
Can-Dive Services Ltd.

1966 - 1969

Founder and President Can-Dive Services Ltd.

1964 - 1966

Director, Triton Engineering and Marine
Construction Ltd.

1960 - 1964

Director, Industrial Marine Divers

1958 - 1960

Supervisor, Pacific Divers Ltd.

Project Related Experience

During the period 1967 - 1977, Nuytten was involved in:

- Installation of the first Canadian HeO₂ Bell diving complex aboard the drilling rig SEDCO 135-F.
- Co-Manager of project "NESCO" - World's first working, ocean dives to 600 ft. - Santa Barbara Channel.
- Project Manager for construction of the MARK 3 - Oceaneering's first full saturation diving complex.
- Wrote Protocol and participated in project "Deepwork 1000", 2 year series of saturation test dives to 1000 ft. - North Carolina.
- Principal investigator for deep dive portion of "Arctic IV" expedition. First HeO₂ dives conducted in Canadian high Arctic for the purpose of testing proprietary HeO₂ equipment.
- Co-developed a design for a 1000 ft. saturation complex to be used in association with the lock-out submersible SDL-1 - Canadian Armed Forces.

DESIGNATIVE:

- Designed "BC-1", 600 ft. roll-out bell system for offshore petroleum exploration support.
- Developed the concept of a submarine-mounted full saturation diving system for use on the submersible "Auguste Piccard" - Horton Maritime Exploration.

CONSULTANT TO:

DCIEM - Defense and Civil Institute of Environmental Medicine.

EDU - Experimental diving unit, Washington, D.C.

NATO - North Atlantic Treaty Organization.

Seneca College, Toronto
University of British Columbia
Simon Fraser University
Fleet Diving Unit, Pacific Association of Mechanical Engineers
U.S. Army Corps of Engineers

MEMBER OF:

Association of Diving Contractors
Marine Technology Society
Underwater Society of America
HeO₂ Divers Association
National Geographic Society
International Oceanographic Society

SERVES ON:

- Diving Standards Formulation Board - Workers' Compensation Board of B.C.
- Canadian Deep-Dive Facility Steering Committee, Toronto, Ontario.
- Diving Systems Group - Canadian Standards Association, Rexdale, Ontario.
- Ocean Industry Task Force - Ottawa.
- Diver Training Facility Committee - Province of Newfoundland.
- Chairman, Local 2404, Divers Union.

Nuytten is tasked with Oceaneering's corporate responsibility for the technical over-view of innovative sea-floor machines and techniques, including:

- Remote Controlled Vehicles
- One Atmosphere Suit Development
- Manipulator Bells
- Submersibles

PUBLICATIONS

Nuytten has authored dozens of magazine articles and technical papers over the past ten years. He has prepared and given formal technical papers at:

- Offshore Technology Conference - Houston, Texas
- OECON - Long Beach, California
- Oceans 77 - Los Angeles, California
- International Diving Symposium, New Orleans
- Working Diver - Columbus
- Canadian Diving Conference - Ontario
- Man in Cold Water - Ontario

DIVING
BACKGROUND

Nuytten has been heavily involved in all phases of commercial diving for the past twenty years. He has logged thousands of hours underwater as manager of numerous underwater construction projects, involving diamond drilling, controlled blasting, major excavations ship salvage, high-pressure grouting, dock and dam rehabilitation, marine pipelines, petroleum exploration support, anti-scour devices, underwater television and photography projects.

CONFIDENTIAL RESUME

PERSONAL:

NAME: Paul Thomas Mockler
DATE OF BIRTH: September 3, 1944
SOCIAL INSURANCE NUMBER: 421-853-607

EDUCATION:

1951 - 1959 Primary School, Hamilton and Waterdown
Province of Ontario
1959 - 1964 Waterdown District High School
Waterdown, Ontario
Grade 13 Diploma
1965 - 1969 Ontario College of Art
Diploma in Advertising
Major - Photographic Design

CAREER HISTORY:

1979 to Present (Freelance)

Underwater Cinematography
Canadian Broadcasting Company's
"Fifth Estate" and "Nature of Things"

Director, Writer, Cinematographer for C.B.C.'s
This Land: "Eyes of the Totem"
N.W. British Columbia

Underwater Cinematographer
"SKW", Lake Huron, Ontario
"SKW" Trostburg, West Germany

Course Director of Underwater Photo/TV Program
Canadian Underwater Training Centre
Toronto, Ontario

1978

Director, Cinematographer
"Armed for Deep Water"
Oceaneering International
Off-shore, Labrador

Wildlife Cinematographer for:
C.B.C.'s "This Land" series
"The Predators", "Ducks Unlimited", "King of the Bush"
"Damn the Beaver"

CAREER HISTORY: (continued) 1977 - 1978

Director, Writer, Cinematographer
"Treasure of Grand Bahama"
Underwater Explorers Society
Freeport, Bahamas

1978

Underwater Cinematographer
Special Features
Channel 10 TV News
Miami, Florida

Director of Photo and TV operations
aboard "Sea Otter" submersible during the
"M.V. William Carson" Survey Expedition.
Oceaneering International
Off-shore, Labrador

1976

Director,
"Arctic Jim"
Oceaneering International

Director, Writer, Cinematographer
"Mayreau"
St. Vincent, British West Indies

1975 - 1977

Director, Writer and Cinematographer for
the Canadian Broadcasting Corporation,
prime time series:- "The New Wave".

"The Submarines". Director, Writer and
Cinematographer

"The Searchers". Underwater Cinematographer

"Cities on the Sea". Underwater Cinematographer

"The Great Inland Seas". Cinematographer

"Dive, Dive, Dive". Director, Cinematographer

CAREER HISTORY (continued)

"War on Ice". Cinematographer

"The Last Resource". Underwater Cinematographer

"Plugging in the Oceans". Underwater Cinematographer

"Man in the Sea". Director, Writer, Cinematographer

"Humans ~~in~~ the Sea". Writer, Underwater Cinematograph

"Sunken Treasure". Director, Writer, Cinematographer

"The Sea Workers". Director, Writer, Cinematographer

1974

Head of Photography Department
Ontario College of Art
Toronto, Ontario

Cinematographer for Ocean Life Systems Orcinus
Orca Research Program
Alert Bay, British Columbia

1973

Underwater Cinematographer for
"Classrocm in the Sea"
Freeport, Bahamas
(Wheeler Productions, Washington, D.C.)

Underwater Cinematographer for film on Perry
Oceanographic Submersible Vehicles and Hydro
Lab Habitat.
Riviera Beach, Florida and Freeport, Bahamas

1973 - 1974

Photography Consultant to Ontario Science Centre
and Arough initial experiments and production of
the first holograms at the Ontario Science Centre.

1971— 1974

Photographyr and Photography Consultant to the
Art Gallery of Ontario.

CAREER HISTORY (continued)

1969 - 1974

Instructor of Photography
Ontario College of Art.

1969

Advertising Photography. Some major accounts
have included:

A & M Records. Photography and Photographic Consultant

Toronto Life Magazine

Axe Records

Ontario College of Art

National Gallery of Canada, Ottawa

Cult Magazine

Longman's Publishing

Miscellaneous major artists and art galleries

Richard G. Mason
8 Roanoke Road
P.H. #5
Don Mills, Ontario
M3A 1E6

Phone: (416) 444-3203

EMPLOYMENT

UNDERWATER CINEMATOGRAPHY

Specializing in Arctic Underwater Cinematography

1978 Underwater sequences of the Canadian Olympic Swim-Team for a film titled "The Chiropractors" by Profile Communications, Toronto

Industrial film survey on underwater pressure-ridges in Arctic ice. This was filmed in the Beaufort Sea for Canadian Marine Drilling Co., Calgary, Alberta.

Film titled "Underwater Harvest" for Westminster Films, Toronto

Underwater Cinematographer on a film showing the sinking of the S.S. Stavronikita for the Barbados Tourist Board and Chetwynd Films

1977 "Life-line" episode in the "Search and Rescue" seriesCTV-NTA (NBC)

Second Unit underwater camera operator for Arctic sequences in DeLaurentiis feature "ORCA"

1976 Harp Seal film made by the University of Guelph in
and the Magdalen Islands - Gulf of St. Lawrence. During
1977 this expedition, the first underwater footage of the Hood-Seal was taken

1975 Arctic Mammal IV Expedition for Undersea Research led by Dr. J.B. MacInnis to Baffin Island, N.W.T.

This expedition was the first to photograph Narwhals underwater and a film titled "The Narwhals Came" was made about the expedition. This film won best nature and wildlife category at the Canadian Film & Television Association awards.

- 1975 Underwater photographer during the dive that His Royal Highness Charles, Prince of Wales made at Resolute Bay
- 1975 Underwater cinematographer during the dive that Pierre E. Trudeau, Prime Minister of Canada made at Resolute Bay
- 1974 Underwater Television camera operator on a Union Carbide commercial titled "Diver" produced by Glen-Warren Productions for Gordon Hill Advertising Agency, Toronto
- 1974 Underwater Cinematographer for the National Film Board of Canada on the MacInnis Foundation's Arctic IV Expedition to Resolute Bay, N.W.T.

A film titled "Arctic IV" was produced by The National Film Board illustrating the following projects undertaken by the expedition

1. The first expedition to dive beneath the polar ice cap at the geographic North Pole
2. A 24 hour saturation dive beneath the ice at Resolute Bay
3. A deep helium dive to 225 feet beneath the ice in Barrow Strait
4. Placing of the underwater station, SUB-IGLOO, on the ocean floor, under the ice in Resolute Bay. Conducting 16 scientific projects including biology, geology and oil-under-ice studies.
5. Underwater television camera operator on the first live telecast from beneath the Arctic Ocean on the CBC production "The Presence of Man"

- 1973 Underwater cinematographer for the Environmental Defence Fund's Bowhead Whale Expedition to Point Barrow, Alaska. During this expedition a film was made on the bowhead whale by the National Film Board titled, "In Search of the Bowhead".
- 1972 Surface and underwater cinematographer for the Arctic III Expedition of the MacInnis Foundation to Resolute Bay, N.W.T.

The film "SUB-IGLOO" was produced by the National Film Board of Canada from the footage shot on this expedition and won first in its category at the Bordeaux Film Festival in October 1974.

- 1970 Member of an underwater archeological team who completed a survey and artifact recovery on the wreck, "Marion L. Breck" for the Royal Ontario Museum and the Historical Sites Board

Diver Training

- 1973 Received training on the General Electric Mark X rebreathing system on the Arctic III Expedition
- 1971 100 hour N.A.U.I. course taken at the Brooks Institute of Photography during the Undersea Photographic Technology course. This included training in the Aquadyne helmet and band mask.
- 1970 Graduate of the Ontario Underwater Council's program in Underwater Archeology
- 1968 40 hour N.A.U.I. course taken at the Canadian Sub-Aqua Club in Toronto

PERSONAL

Education

Brooks Institute, Santa Barbara, California
1971 - Undersea Photographic Technology

Ryerson Polytechnical Institute, Toronto
1959 - School of Radio and Television Arts

Additional

Date of Birth: October 8, 1935
Marital Status: Married
References available upon request

Member, Canadian Society of Cinematographers
Member, Society of Television Lighting Directors
Member, Fitness Institute (Willowdale)

R. FRANK BUSBY

Education:

Bachelor of Science degree--American University; Washington, D.C., 1958
Major: Geology.

Master of Science degree--Texas A&M University, College Station Texas, 1960
Major: Oceanography

Pertinent Work History:

1958-1960

Graduate Research Assistantship, Oceanography Dept., Texas A&M. (Assisted in work on: radio-active waste disposal, geology of the Campeche Bank, sediment and reef corals of Cayo Arenas, Campeche Bank.

1960-1961

Oceanographer, Field Section, Naval Oceanographic Office. Participated in deep-sea surveys in support of classified projects and the Atlantic Undersea Test and Evaluation Center (AUTEC) project. Duties included sediment coring, salinity; oxygen, and phosphate analysis, current measurements, sound velocity measurements and bathymetric mapping. Laboratory duties included performing engineering (bearing strength) analyses, grain size measurements and geochemical analyses. Office duties consisted of interpretive reporting of the results of such analyses.

1961-1966

Oceanographer, Project AUTEC, Naval Oceanographic Office. Responsible for planning and conducting all geologic surveying, sampling, analyses and reporting in support of Project AUTEC. From October 1962 to June 1963 resided in Nassau Bahamas and conducted research into the physical-chemical properties and dynamics of the Eastern Great Bahamas Banks shoal waters; concurrently served as liaison officer between Decca Navigator Co. and the Naval Oceanographic Office. Served as senior scientist aboard a variety of surface vessels conducting deep-water current surveys, dye dispersal studies and bathymetric mapping; shallow-water sediment, current, tide and channel and cable route bottom surveys. Completed U.S. Navy Diving School in 1965; subsequently planned and executed a sediment erosion-deposition study of the channels and shoreline bordering the AUTEC sites. Conducted the first Naval cable route survey using a manned submersible (Perry CUBMARINE) in June 1965. During the period 1961-1966 spent approximately 6 months annually at-sea and supervised scientific parties ranging from 4 to 12 in number. Office duties consisted of directing and conducting analyses of data from the previous survey and preparation of operating specifications for the subsequent survey.

Served as AUTECH project leader for seven months in 1965-1966; duties included administration of funds, overall program execution and long range planning for future AUTECH studies.

1966-1971

Project head, Deep Vehicles Branch, Naval Oceanographic Office. Responsible for the planning, conducting and reporting of a project whose goal was to provide design specifications, operational procedures and oceanographic instrumentation for a 20,000 foot, depth-capable Deep Oceanographic Survey Vehicle. This eventually amounted to the administration of funds totaling approximately 4 million dollars and the supervision of a staff of fifteen. Planning work consisted of determining the types of undersea surveys the Navy might conduct, the instrumentation which would be required and the writing of operational specifications to conduct this work on a variety of manned submersibles. Additional work in this vein consisted of writing the technical requirements for Requests for Proposals from contractors and the subsequent technical evaluation of these proposals. During the operational (at-sea) phase of the project served as senior scientist and directed the efforts of project personnel both for the submersible and from aboard the support ship. This work resulted in diving in the submersibles Perry CUBMARINE (Bahamas), ALVIN (Bahamas), ALUMINAUT (Florida, Virgin Islands, Puerto Rico), DEEPSTAR-4000 (Conn. to the Panama Canal Zone), DEEP QUEST (Santa Barbara Channel & San Clemente Island). Served as senior oceanographer aboard BEN FRANKLIN during a 30-day Gulf Stream Drift; constructed the mission profile and participated in the contract negotiations for the multi-participant operation. Temporary detail to the Naval Ships System Command Submersible Certifying Group (PMS-810) and performed as certifying officer on BEN FRANKLIN's certifying dive.

Subsequent to all sea going operations directed evaluation efforts of the vehicles and instruments and provided the format and subject direction of final reports.

Additional duties in this position resulted in participating in a variety of Navy submersible study groups (e.g., IDOE submersibles lease program) and presented numerous briefings of the project's progress to pertinent Naval activities. Have presented lectures to colleges (M.I.T., Catholic U., Florida Atlantic U., George Washington U.) and various Naval Activities (Naval War College, Supervisor Salvage Officer Training Course) on deep submersibles and their applications.

The result of these five years provided a broad and detailed background in oceanographic instrumentation and techniques, manned submersibles, engineering problems in undersea vehicles and undersea components, and personal appreciation for where the submersible, the towed vehicle, or the surface ship is best employed in ocean surveying.

1971-1972

Branch Head-Geology/Geophysics Branch, U.S. Naval Oceanographic Office. Responsible for the planning, conducting and reporting of marine geological

and geophysical data in support of Naval requirements. Position includes the administration and supervision of 30 professional oceanographers; the instrumentation outfitting and updating of three survey ships (AGS-type) and the routine budgeting/planning for short and long-range survey and equipment requirements.

Nature of surveys involves deep water coring, seismic profiling, bathymetric profiling and gravity/magnetics profiling.

Personally conducted a shallow-water cable route survey in which the goal was to determine "plowability" of the bottom. Employed side scan sonar, high resolution sub-bottom profiler, narrow-beam bottom profiler, underwater television and cameras, and bottom samplers. The results of this survey included treatment of all oceanographic factors dealing with design, installation and operation of submarine cables.

1973-1974

Conducted research into the design, construction, operation and support of manned submersibles throughout the world. The results of this one and a half (1½) year effort were published in 1975 by the Government Printing Office entitled "Manned Submersibles." Its purpose is to serve as a reference and source book for the participants of deep submergence and as an introduction to the subject for new-comers to this field.

Consultant and Advisor to:

National Academy of Engineering, Marine Board
Texas A&M University, Oceanography Department
Westinghouse Electric Corp., Ocean Research and Development Laboratory
International Hydrodynamics Ltd.
Horton Maritime Explorations Ltd.

1975 to present

Director R. Frank Busby Associates.

PUBLICATIONS

1962--Subaerial features on the floor of the Tongue of the Ocean, Bahamas.
U.S. Naval Oceanographic Office, IMR 0-48-62

1962--Submarine geology of the Tongue of the Ocean, Bahamas. U.S. Naval Oceanographic Office, Technical Report No. 108

1964--Oceanography of the Eastern Great Bahama Bank. Pt. 1. Temperature-Salinity distribution. U.S. Oceanographic Office. Technical Report No. 174 (Co-authorship with G.S. Dick, Jr.)

1965--AUTECH Oceanography. Undersea Technology, v.6, n.7, p. 38-42.

- 1966--Sediments and reef corals of Cayo Arenas, Campeche Bank, Yucatan.
U.S. Naval Oceanographic Office, Technical Report No. 187
- 1966--Ocean bottom reconnaissance off the east coast of Andros Island, Bahamas.
U.S. Naval Oceanographic Office, Technical Report No. 189 (Co-authorship
with C.V. Bright and A. Pruna)
- 1966--Submarine geology of the Tongue of the Ocean, Bahamas, Proc. 2nd Inter-
national Oceanog. Congr., Moscow, p. 74 (abstract)
- 1966--Sea floor navigation for deep submergence vehicles. Jour. Inst. Nav.,
v. 13, n. 2, p. 141-145 (Co-authorship with W. Hart)
- 1967--Undersea retrieval of instruments with the DRV Aluminaut. Geo. Mar.
Tech., v. 3, n. 5, p. 41-44
- 1967--Sea floor strength observations from the DSRV Alvin in the Tongue of
the Ocean, Bahamas. Southeastern Geology, v. 8, n. 1, p. 1-8
(Co-authorship with J.B. Rucker and N.T. Stiles)
- 1967--Undersea studies with the DSRV Alvin, Tongue of the Ocean, Bahamas.
U.S. Naval Oceanographic Office, IMR No. 67-33 (Co-authorship with
R. Merrifield)
- 1967--Undersea penetration by ambient light and visibility. Science, v. 58,
n. 3805, p. 1178-1179
- 1968--Ocean surveying from manned submersibles. 12th International Congr.
of Surveyors, London, Sept. 1968
- 1968--Performance and design of manned submersibles. Amer. Soc. Mech. Eng.
Winter Meeting. New York, December 1968
- 1968--Environmental hazards to submersible operations. Ocean Industry, v. 3,
n. 7, 8, 9 (Co-authorship with W.O. Rannie and L.M. Hunt)
- 1968--Submersible measurements of sediments. Northeast Electronics Research
and Engineering Meeting, Boston, Nov. 1968 (Co-authorship with M.A. Ransom
and E.H. Shenton)
- 1969--Ben Franklin's mission-Gulf Stream Drift. Undersea Technology, May 1969
- 1969--Safety in the depths. Ordnance, v. 8, n. 293
- 1969--Manned submersibles. 1970 Oceanology Yearbook, Oceanology International
- 1970--Benefits of manned submersibles to military oceanography. Trans. 7th
Annual Symp. on Mil. Oceanog., v. 1, p. 273-298
- 1970--Oceanographic instrumentation on the submersible Ben Franklin. Trans.
6th Mar. Tech. Soc. Conf., v. 2, p. 1041-1077

- 1970--Mass property variability in three closely spaced deep-sea sediment cores. Jour. Sed. Pet., v. 40, n. 3, p. 1038-1043 (Co-authorship with G.H. Keller and R.H. Bennett)
- 1970--Undersea surveying with a manned submersible. Military Engineer, v. 63, n. 44, p. 1-4
- 1970--Manned submersibles and ocean surveying. U.S. Naval Oceanographic Office Special Pub. 153, 156 p., 93 figs. (editor and contributor)
- 1971--Manned submersibles. In The Deep Ocean, Arthur Baker Co., Ltd., London, p. 91-94
- 1972--Diver, Submersible or Instrument Package? Underwater Jour., June, v. 4, n. 3, p. 115-123
- 1972--Manned submersible limitations and capabilities in ocean exploration and surveying. Natl. Acad. Eng. Background papers for Ocean Exploration and Surveying, 1975-1985, v. II, 18p.
- 1972--Oceanology from manned submersibles Nautilus, Documenta Geigy 12.
- 1972--Taxis to the Deep in World Beneath the Sea. National Geographic Society Special Publication.
- 1976--Manned Submersibles. Special Pub. No. 102, Office of the Oceanographer of the Navy, GPO Stock No. 008-042-00063-2, 764 p.
- 1977--Unmanned submersibles. In, Submersibles and Their Use in Oceanography, Elsevier Publishers, Amsterdam, p. 23-59.
- 1977--Engineering aspects of manned and remotely controlled vehicles. Paper presented to the Royal Society's conference "Sea Floor Development - Moving Into Deep Water", London, 1-2 June 1977.
- 1978--Underwater Inspection/Testing/Monitoring of Offshore Structures. Conducted under Department of Commerce Contract No. 7-35336, Government Printing Office, Washington, D.C. 139 p.
- 1978--Federal Civilian Agency Manned Undersea Program Identification, Description, and Facility Requirements. Unpublished manuscript conducted for Department of Commerce, Washington, D.C. 155 p. with Appendices.
- 1979--Remotely Operated Vehicles. Conducted under Department of Commerce Contract No. 03-78-G03-0136, Government Printing Office, Washington, D.C. 150 p. with Appendices.

J. MICHAEL COSTIN

Education: B.S. University of Nebraska, Lincoln, Neb., 1960
Major: Geology; 2nd Major: Literature
Minors: Math and Chemistry

Graduate Courses - Columbia University, New York, 1963-1965
Oceanography, Computer Science and Applied Mathematics

Relevant Work History:

1961-1967

Lamont-Doherty Geological Observatory of Columbia University, New York. Research assistant in oceanography. Worked on development and use of new oceanographic instrumentation and field study techniques specifically designed for measurement of oceanic circulation and mixing. Worked primarily in the North Atlantic and in the Atlantic Missile Range areas. Duties included planning, conducting and management of long-term oceanographic studies as well as data reduction, analysis and presentation of reports to supporting governmental agencies. Responsible, as field party chief in oceanographic studies of diffusion and circulation, for acquisition and management of ships and aircraft used to conduct these studies. Participated in development of optical oceanographic sensors and related data recording systems. Developed computer programs for analysis of circulatory and mixing data. Authored several papers regarding the work and equipment especially developed for the client.

1967-1970

Physical oceanographer, Deep Vehicles Branch, United States Oceanographic Office. Served as a physical oceanographer in a program designed to test and evaluate manned submersibles as operational platforms for performance of oceanographic research. Responsible mainly for physical oceanographic and optical measurements but also was required to make geological and biological investigations as a routine part of underwater operations. Duties included installation and operation of a great variety of oceanographic, acoustic and optical equipment.

Attended U.S. Navy Diving School and was graduated as a Navy-qualified diver in 1968. Participated in underwater research directed at improving deep-water or nighttime photography. Developed several computer programs for analysis of oceanographic data, especially related to submersible instrumentation, but applicable to any related equipment or studies.

1970-Present

Consultant and equipment designer-operator for several types of oceanic and inland water studies. Developed and patented a submersible fluorometer for use in mixing studies. Has been involved as director and field manager for the following types of studies: mixing, circulation and transport of water and water-borne materials through the use of fluorescent tracers and standard current sensors; sedimentation

HAEL COSTIN

sent (Continued)

s, transport and accumulation, particularly in rivers and inland waters (estuaries); dredge discharge monitoring; optical water quality assessment (transparency, turbidity and color); sampling and format scheduling and management; outfall and industrial site engineering and study; lake, river and coastal survey, monitoring sampling; management of field personnel and equipment; stream-flow and water-management studies and consultation; aerial surveys (photography and thermal monitoring); aquaculture site evaluation and procedural assessment and instrumentation for automated monitoring and control. Studies have been primarily related to technical aspects of the above tasks, but has also prepared several computer programs for data reduction and analysis of these and related systems. Has authored over 30 reports to clients related to these field studies. Has participated in all aspects of the studies: contractual, negotiations, leasing or developing of equipment, management of field study programs, data analysis and subsequent report preparation presentation.

JOSEPH POLLIO

Education:

Bachelor of Science degree--George Washington University; Washington, D.C.
1965

Major: Geodesy

Graduate Study--George Washington University; Washington, D.C. 1965-1969

Areas of Study: Geodesy and Ocean Engineering

Master of Science degree--Florida Institute of Technology; Melbourne, FL
1976

Major: Physical Oceanography

Pertinent Work History:

1949-1956

Cartographer, U.S. Coast and Geodetic Survey, Department of Commerce.
Hydrographic chart construction cartographer.

1956-1959

Photogrammetrist, U.S. Naval Hydrographic Office. Chart construction shoreline interpretation, position control data reduction.

1959-1968

Instructor, U.S. Naval Oceanographic Office. Hydrographic, geodetic, geophysical and oceanographic surveys and topics.

1968-1970

Deputy Director, Deep Vehicles Branch, U.S. Naval Oceanographic Office. Designed, participated and conducted surveys with several different submersibles: PERRY CUBMARINE, ALUMINAUT, STAR III, DEEP QUEST, and BEN FRANKLIN.

1970-Present

Branch Head, Special Projects Branch, U.S. Naval Oceanographic Office. Administers, plans and conducts at sea operations with the towed vehicle TELEPROBE. This work includes deep water (10,000 - 20,000 ft) stereo-photogrammetric mapping, side scan sonar surveying and bathymetric profiling.

PUBLICATIONS

1968--Stereophotogrammetric Mapping from Submersibles, Proc. Soc. Photo-Optical Instru. Eng., Underwater Photo-Optical Instrumentation Applications, San Diego, CA, Vol 12, p. 67-71

- 1969--Applications of Underwater Photogrammetry, Marine Technology Society, Journal Vol No 1, Jan 1969, p. 55-72 (This paper was presented at the National Symposium of Underwater Photography June 1968 at which I was the Chairman of the Applications Session.)
- 1969--Photogrammetric Applications to Undersea Tasks, Soc. of Motion Picture and Television Eng., Journal of the SMPTE, Vol 78, Mar 1969, p. 152-157
- 1971--Underwater Mapping with Photography and Sonar, American Society of Photogrammetry, Photogrammetric Engineering, Vol XXXVII No. 9, Sept 1971, p. 955-968
- 1972--Remote Underwater Systems on Towed Vehicles, American Society of Photogrammetry, Photogrammetric Engineering, Vol XXXVIII No. 10, Oct 1972, p. 1002-1008
- 1979--A model Analysis of Underwater and Visibility Systems from Observed Data, Proc. Soc. Photo-Optical Instrumentation Engineers, in print

Can-Dive Services Ltd. is a Canadian company, registered in British Columbia, Ontario, Northwest Territories, and Newfoundland and is the Canadian joint-venture partner of Oceanair International, London, Texas.

APPENDIX D

Can-Dive Services Ltd. (C.D.S.L.) was formed in 1961 and maintained offices in North Vancouver, B.C., Mississauga, Ontario, and St. John's, Newfoundland.

Company History

In 1965, C.D.S.L. joined with other major diving companies to form Oceanair International, Ltd., which has grown to become one of the world's largest independent offshore diving and diving contractors. C.D.S.L. has been active in deep water diving, including the installation of offshore diving and diving systems and diving systems.

Can-Dive Services Ltd. has been involved with the majority of oil companies who have conducted offshore exploration operations in Canada, operating with Shell Oil Canada on the SENECA field.

Early diving operations based in St. John's, Newfoundland, included over 100 dives in waters from 100 ft. to 1,000 ft. British Petroleum on board the ship - SENECA-1, SENECA-2, SENECA-3, and SENECA-4, at depths of 400 ft.

In 1973, Can-Dive Services performed dives to 1,000 ft. for Chevron Canada Ltd. on board the Can-Dive Limited off Nova Scotia utilizing the atmospheric diving bell, Ocean Air-1. Additional dives have since been made to depths of 1,000 ft. off Labrador, and to 1,200 ft. in the Davis Strait off Baffin Island.

To date, over 700 dives have been made in the Arctic to support exploration activities of Canadian Marine Drilling Ltd. and Canadian Oil Ltd. Over 100 dives have been made in the Arctic region, three 400 ft. fixed depth dive systems, one 1,000 ft. fixed depth dive system, and one 1,200 ft. portable launch dive system.

A specially built dive system was utilized during the recent Panarctic Film Inc. Iceberg Filming Project. This system, with depth capability of 400 ft., was completely Modular Aircraft Transportable, and fully self-contained and self-sufficient for Arctic water operation (January - April).

COMPANY BACKGROUND

Can-Dive Services Ltd. is a Canadian company, registered in British Columbia, Ontario, Northwest Territories, and Newfoundland and is the Canadian joint-venture partner of Oceaneering International, Houston, Texas.

Can-Dive Services Ltd. (C.D.S.L.) was formed in 1966 and maintains offices in North Vancouver, B.C.; Mississauga, Ontario; and St. John's, Newfoundland.

In 1969, C.D.S.L. joined with three other major diving companies to form Oceaneering International, Inc., which has grown to become one of the world's largest independent diving contractors and a leading innovator in deep water work techniques, including ambient pressure diving and one-atmosphere and remote control systems.

Can-Dive Services Ltd. has been involved with the majority of oil companies who have conducted offshore exploration operations in Canada, commencing with Shell Oil Canada on the SEDCO 135F.

East Coast operations based in St. John's, Newfoundland, included over 800 dive exposures for Mobil Oil, Amoco, British Petroleum on board the rigs - Sedco-1, Sedco-J, Sedco-H, and Sedneth-1, to depths of 400 ft.

In 1978, Can-Dive Oceaneering performed dives to 2800 ft. for Chevron Canada Ltd. on board the Ben Ocean Lancer off Nova Scotia utilizing the on-atmosphere manipulator bell, Ocean Arms-1. Additional dives have since been made to depths of 1800 ft. off Labrador, and to 1200 ft. in the Davis Strait off Baffin Island.

To date, over 1000 dives have been made in the high Arctic to support exploration activities of Canadian Marine Drilling Ltd. and Panarctic Oils Ltd. Dives utilize specially built surface supplied gear; three 650 ft. rated bounce dive systems; one 1000 ft. rated bounce/saturation dive system, and one 500 ft. portable bounce dive system.

A specially built dive system was utilized during the recent Panarctic Oils Ltd. Drake Flowline project. This system, with depth capability of 500 ft., was completely Hercules Aircraft transportable, and fully self-contained and winterized for Arctic winter operation (January - April).

Dives have also been made to depths of 905 ft. for Panarctic Oils Ltd., utilizing the atmospheric diving system (ADS) "Jim". A remote control vehicle is currently operating in depths to 1500 ft. in the Davis Strait and the Ocean Arms 1 system is supporting Global Marine/Chevron operations off Newfoundland.

Can-Dive has participated in a number of scientific and industrial programs throughout Canada and in the Arctic, and offers a full range of diving, deep diving, one-atmosphere, and Oceanographic survey services.

Can-Dive Services Ltd. has worked closely with various Federal and Provincial agencies, including D.N.D. and D.C.I.E.M., as consultants regarding diving operations and regulations.

Can-Dive Services personnel have been instrumental in the design, development and commissioning of many innovative work systems utilized world wide by Oceaneering International, including; deep dive system design; participation in and supervision of deep dive physiological experiments; development of advanced diver support apparatus, (helmets, heating systems, life support systems, etc.); bell and work vehicle handling systems and one-atmosphere work systems (Jim, Sam, Wasp).

As a major operator of deep dive systems, Can-Dive Services has years of practical experience in the operation of these systems and first hand knowledge of the many problems and subsequent modifications necessary to allow a project to achieve its objectives.

Throughout its history, Can-Dive Service personnel have undertaken thousands of underwater inspections on virtually every type of underwater structure. These inspections have included the use of motion and still photography, as well as video recordings. These commercial diving techniques have also been employed in scientific investigations throughout Canada, (i.e. Mac Innis Foundations Arctic II, III, IV Expeditions.)

APPENDIX E

Alternative Methods: Cost Structure

ALTERNATIVE METHODS; COST STRUCTURE

If the use of an untethered submersible is undesirable and the contracting representative decides to use a tethered submersible or remote controlled vehicle, Can-Dive would like to submit the following:-

(A) WASP SYSTEMS

The WASP is a one atmospheric submersible similar to the "JIM" system capable of maneuvering mid-water. This system would be capable of carrying out almost 80% of the tasks that either a diver or a submersible could do. As with all systems, a back-up system will be required to recover the WASP should fouling occur. The cost structure is as follows:

Mobilization & installation on vessel -----	\$4500.00
Daily operating rate of Crew -----	\$2250.00/ day
Standby rate -----	\$1200.00/ day
Demobilization -----	\$4500.00

Either the bell diving system or the submersible can be used as back-up.

(B) REMOTE OPERATED VEHICLE

A remote operated vehicle capable of performing similar functions as the submersible can be supplied by Can-Dive Services. Availability of these systems is contingent on their work schedules. As a result, three systems are presented:

TROV System #1 with acoustic positioning & operators -----	\$5225.00/ day
AMATECH Stroya RCV -----	\$3350.00/ day
TROV II with operator -----	\$2200.00/ day

Mob/demob charges depend on which vehicle is available. These figures can be supplied once the contracting representative has decided on which method he chooses to pursue.

(C) ADDITIONAL COSTS

The Klein Side Scan is available (including spares) as follows:

Weekly rate-----	\$2500.00
Additional days -----	500.00/day
Mob/demob -----	1015.00
300 m. cable with winch (1 month min)	3350.00/ month
Operator (expenses add'l at cost)	405.00/day
Freight (estimated)	2250.00 return

The OSEL WASP Submersible

WASP offers low operating costs and freedom from physiological problems associated with saturated diving. It can be used as an inspection unit, camera or sophisticated tool for repair and maintenance on sub-sea structures

WASP can operate for short periods of time independent of external support, having its own power and life support system

Weighing only 500 Kg in air and measuring 2.1 m in length, WASP is easy to manoeuvre and small enough to work in confined conditions - in fact to work on any sub-sea equipment

WASP has two independent breathing systems. The built in life support system operates at 1.05 atmospheres, providing 8 hours endurance in fully automatic conditions and 36-54 hours on semi-automatic using an oral nasal mask.

WASP is able to move in all directions and can rotate clockwise and anti-clockwise by means of foot controls. Attitude indicators are incorporated into the dome and visual trim indicators are mounted in front of the operator.

Trim is altered by varying buoyancy using foot operated pumps and cannot be altered beyond preset limits. In an emergency all externally carried equipment, including the work frame and thrusters, can be jettisoned and 150 lbs of buoyancy is provided

Batteries give 20 minutes of power at full thrust in case of unbilical failure. For safety the operator can cut the unbilical if it becomes snagged on an obstacle and can jettison weight or free swim to the surface.

WASP now has vertical and horizontal thrusters.

able designed to work from surface to seabed, to a maximum depth of 610 m. Operating in currents of up to 1 knot, it is capable of working on or over rough or soft seabeds.

aluminium casting and trunk is made of filament wound resin impregnated tube, with full non-destructive testing on both casting and body tube. Safety factors exceed Lloyd's requirements.

of each dive and two lines of communications are provided by armoured cable which links WASP to the surface.

plus independent audio visual alarm system monitoring all functions and all instrumentation fails, operator has life support available for at least 36 hours and a pressure actuated air lock location.

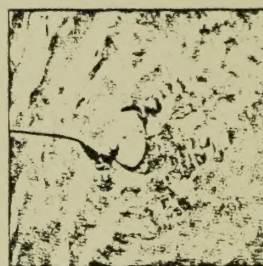
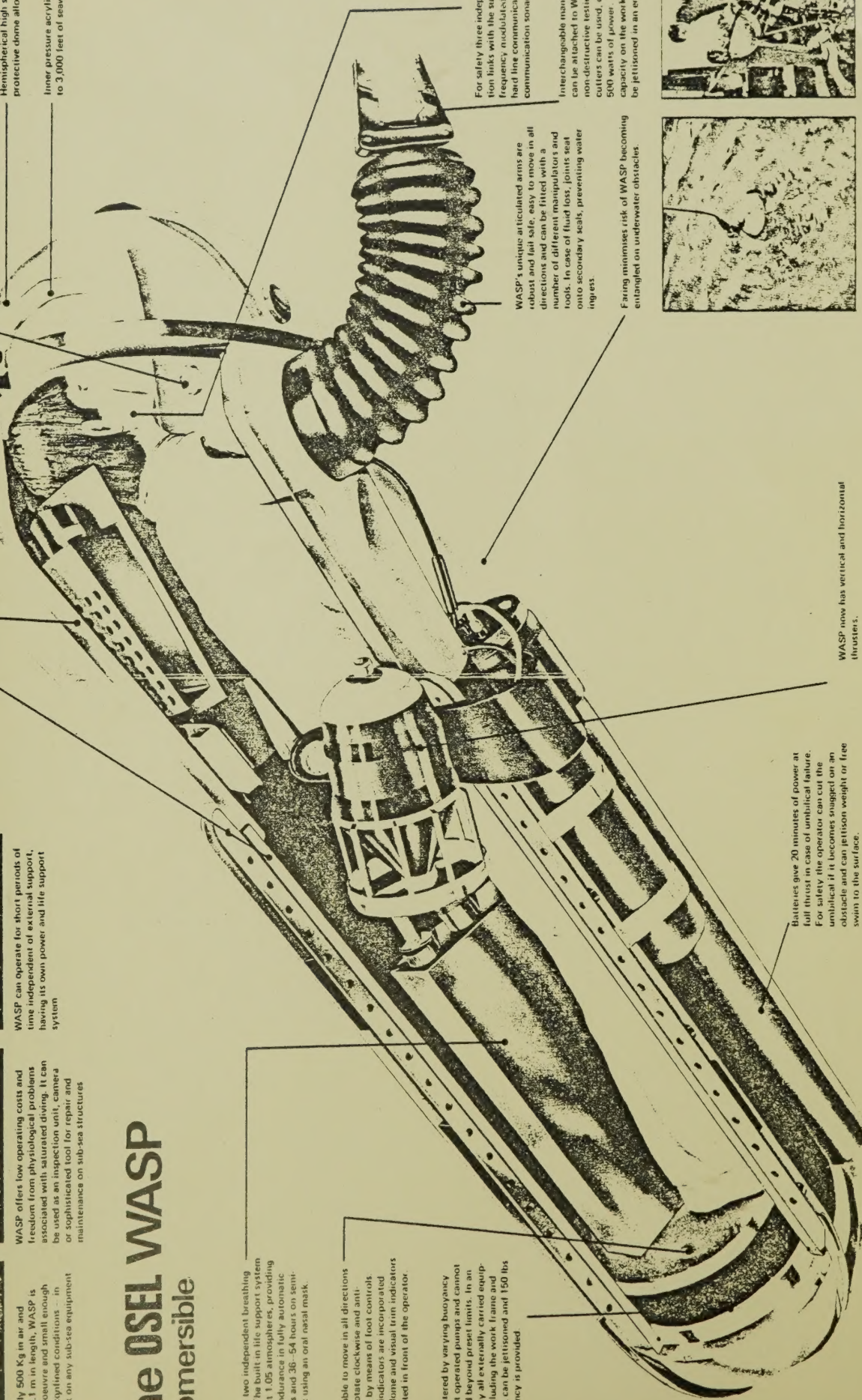
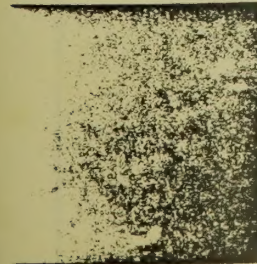
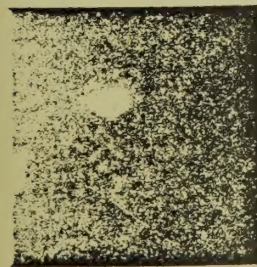
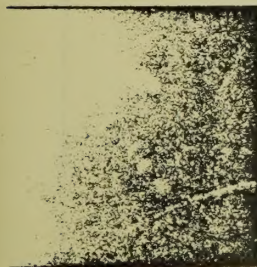
Hemispherical high strength macrolon protective dome allows 360° of vision. Inner pressure acrylic dome, proof tested to 3,000 feet of seawater.

For safety three independent communication links with the surface are provided. Frequency modulated and conventional hard line communications and a Gineasy Communication 'sonar'.

Interchangeable manipulators and tools can be attached to WASP: power tools, non-destructive testing equipment and cutters can be used, drawing up to 500 watts of power. There is extra tool capacity on the work frame, which can be jettisoned in an emergency.

WASP's unique articulated arms are robust and fail safe, easy to move in all directions and can be fitted with a number of different manipulators and tools. In case of fluid loss, joints seal onto secondary seals, preventing water ingress.

Faring minimises risk of WASP becoming entangled on underwater obstacles.



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